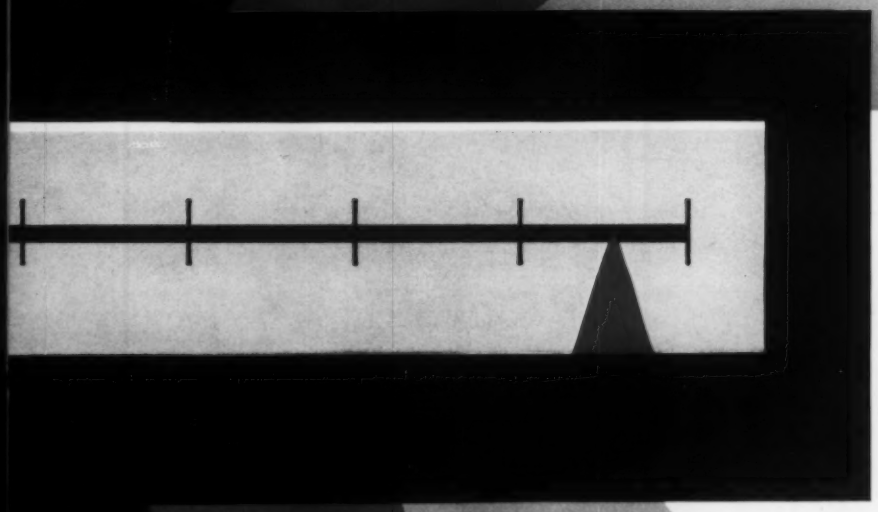
MARCH 20, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Instrument and Panel Lighting

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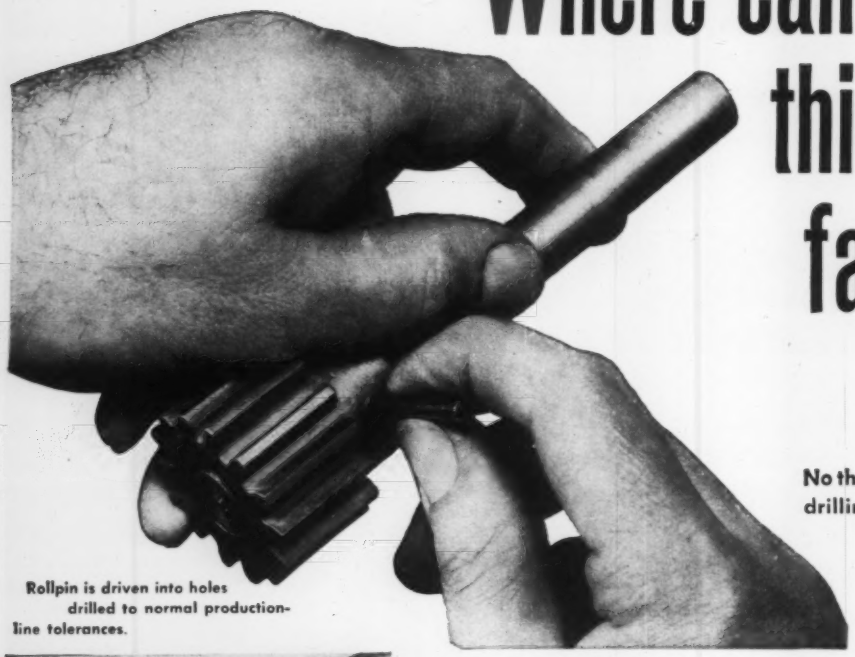
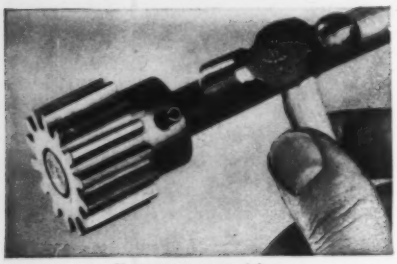
Where can you use this simple fastener?

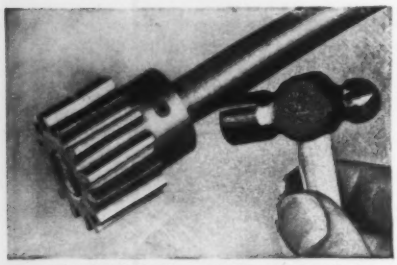


Rollpin is driven into holes drilled to normal production-line tolerances.

No threading, peening or precision drilling with ROLLPIN



It compresses as driven



Rollpin fits flush . . . is vibration-proof

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

This modern fastener drives easily into standard holes, compressing as driven. Its spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole.

* * *

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your costs. Mail our coupon for design information.

Elastic Stop Nut Corporation of America
Dept. R16-34, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ Rollpin bulletin

☐ Elastic Stop Nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State____

Circle 401 on Page 19

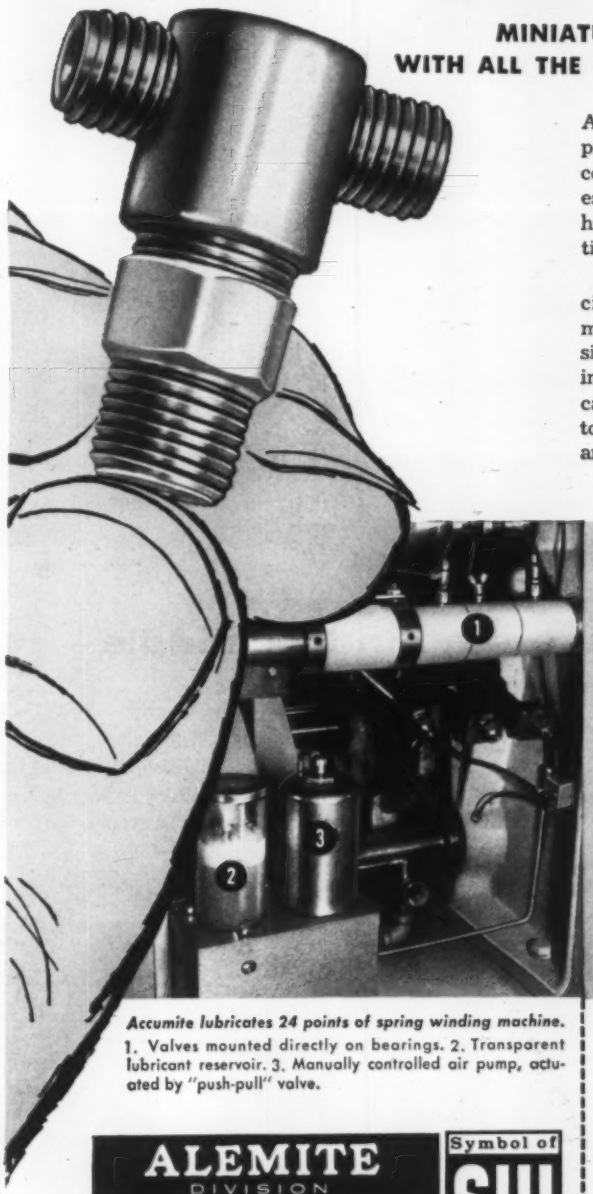
NOW! Any Machine Can Have The Advantages of Centralized Lubrication... At Low Cost!

Alemite "MINIATURE" ACCUMITE System

MINIATURE SIZE FOR LIMITED SPACE—
WITH ALL THE QUALITY OF HIGHER-PRICED SYSTEMS!

Alemite—with 40 years of centralized lubrication experience—announces an all-new miniature system complete with pump, metering valves and controls—especially designed to service many machines and vehicles where centralized lubrication has been impractical until now!

Alemite's new midget-size Accumite system is especially adaptable to light, precision, multiple-bearing machines that have limited installation space. Its small size and simple installation overcomes cost limitations in most plants. Typical applications are: packaging, canning, labeling and textile machines . . . and machine tools. It is also suitable for tractor trailers, lift trucks and farm implements.



Accumite lubricates 24 points of spring winding machine.
1. Valves mounted directly on bearings. 2. Transparent lubricant reservoir. 3. Manually controlled air pump, actuated by "push-pull" valve.

ACCURATELY METERS THESE SHOTS OF OIL OR GREASE

.003 cu. in. **.006 cu. in.** **.009 cu. in.**

ALL THE ADVANTAGES OF "BUILT-IN" MEASURED LUBRICATION—PLUS MIDGET SIZE!

- Meters exact amounts of refinery-clean lubricants to all bearings whenever system is operated.
- Eliminates shutdown time for lubrication.
- Seals lubricant against dirt, grit and water.
- Prevents bearing troubles due to neglect or use of wrong lubricants.
- Services all bearings in one operation.
- Avoids work spoilage and bearing repairs due to overlubrication.

Mail coupon for full information!

ALEMITE
DIVISION
STEWART-WARNER
CORPORATION

Symbol of **SW** Excellence

1850 Diversey Parkway, Chicago 14, Ill.

ALEMITE, Dept. BB-38
1850 Diversey Parkway, Chicago 14, Ill.

Please send me all the facts about your new "Miniature" Accumite system.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 404 on Page 19

You may have met the man in the middle–

He is one of our C/R Sales Engineers. He, or one of his associates, may have been in your plant many times. Here, he's shown helping to check the installation of a C/R oil seal on a Detroit automotive assembly line—*after the seal design has been approved for production.* He wants to make absolutely certain this seal is installed correctly to assure maximum performance and service.

This personal supervision of skilled oil seal engineers and their careful attention to detail, typify every phase of research, design, production and testing of C/R Oil Seals. It accounts for the recognition C/R has earned in sealing applications. And it is a major reason why more automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

If you have a sealing problem, critical or simple, bring it to Chicago Rawhide. C/R engineers will help you select the correct oil seal of existing types or will cooperate with you on a special design.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

C/R OIL SEAL DIVISION

CHICAGO RAWHIDE

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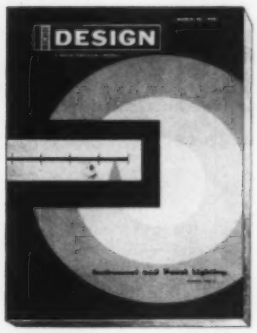

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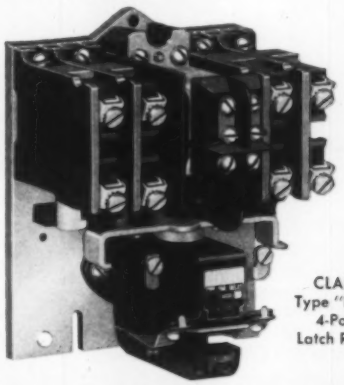
CLARK Type "PML" LATCH RELAYS

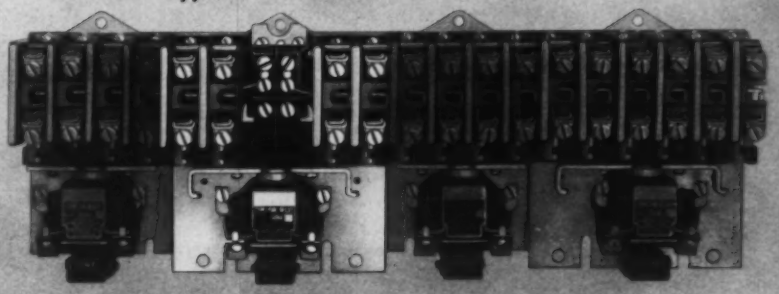
— have all features of CLARK Type "PM" Relays, including SECTIONAL POLE CONSTRUCTION

- **LATCH MECHANISM** replaces 2 poles of Type "PM" relay directly above relay magnet.
- **LATCH ASSEMBLY** easily removed or replaced as a unit by removing wiring and only two screws.
- **LATCH UNIT** has its own magnet—operates independent of relay magnet. No adjustment to get out of order.
- **LATCH COIL** is built for continuous duty—eliminates need for use of relay pole to cut out coil when unit is energized.
- **SPRING-LOADED LATCH** holds contact arm in energized position after relay magnet has been de-energized. Releases only when latch coil is energized.
- **LATCH WEARING SURFACES** are nylon against phenolic—minimizing friction and wear, and assuring longer life.
- **LATCH UNIT** is completely insulated from relay contacts.

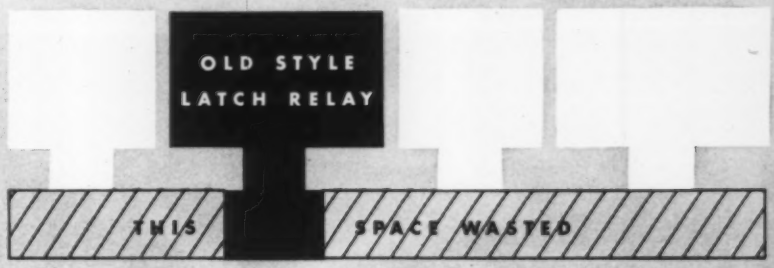


CLARK Type "PML" 4-Pole Latch Relay

CLARK Type "PML" LATCH RELAY



Clark latch relay in row with Clark Type "PM" relays. Note horizontal alignment.



Latching and non-latching relays of conventional design.

NEW!

CLARK Type "PML" LATCH RELAY

saves panel space by lining up with standard CLARK Type "PM" relays

Clark Type "PML" *mechanically held, latched-in* Relays have the same basic "modular" design as Type "PM", which have set new standards for flexibility of panel arrangement and economy of panel space. Contrasted with other latch relays, where the latch mechanism extends several inches below the magnet assembly, they have the same vertical dimensions as corresponding Type "PM" models—lining up perfectly with them, as shown above. The range of models shown below includes sizes and types to meet every demand for a 10-ampere latch relay.

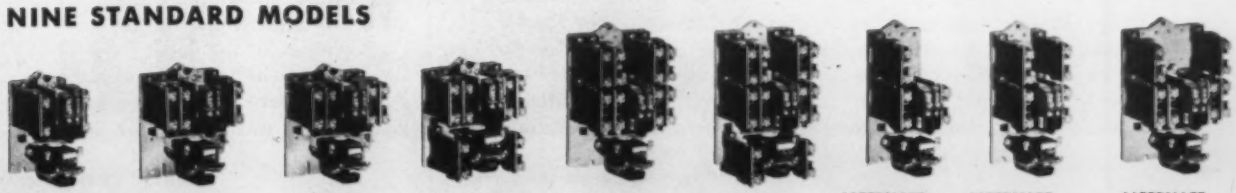
For complete information, write for Bulletin 7305-PML

The **CLARK CONTROLLER** *Company*

Everything Under Control 1146 East 152nd Street • • Cleveland 10, Ohio

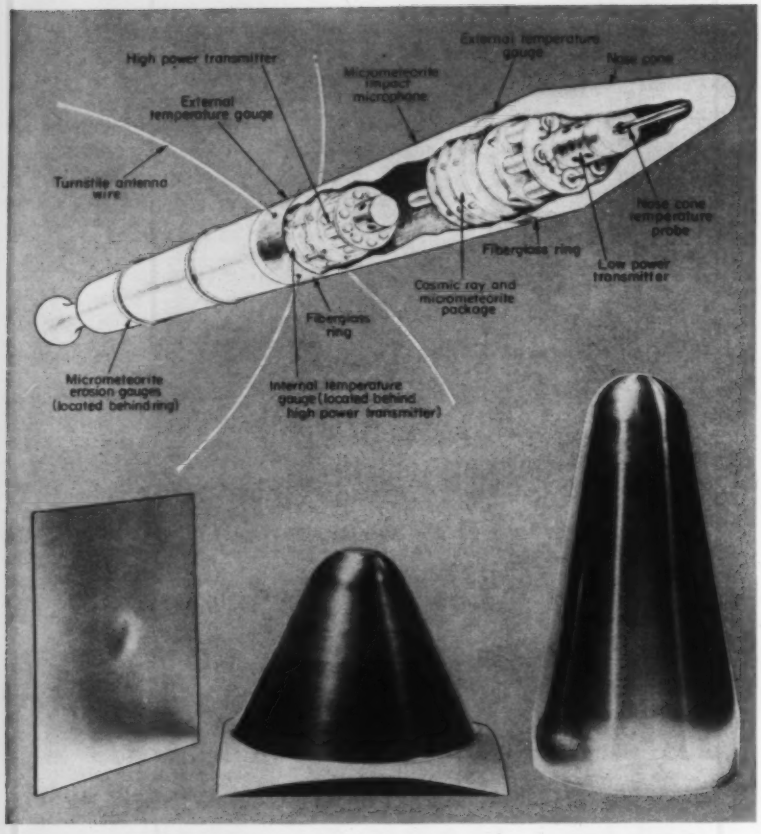
IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

NINE STANDARD MODELS



2 POLE | 3 POLE | 4 POLE | 6 POLE | 8 POLE | 10 POLE | ALTERNATE 3 POLE | ALTERNATE 4 POLE | ALTERNATE 6 POLE

ENGINEERING NEWS



THREE STEPS INTO SPACE are marked with transformation of stainless-steel blank into Army's satellite nose cone. Formed at Lodge & Shipley plant, the cone is now orbiting the earth as the forward end of Explorer I. It weighs only 13 oz. Cutaway drawing of Explorer I shows nose cone with temperature probe inside. Fanning out from midsection is the antenna, made up of whiplike rods with weighted balls at their ends. Both the transmitters relay metered information on eight channels to ground stations.

Develop Superpower Radar For Detecting ICBMs

Power Peak Equals Twenty-One Megawatts

BUFFALO—A radar signal with a power peak of 21 million watts has been hailed as significant in the development of ICBM detection apparatus by a recent Army announcement. The reported radar-like signals, many times more powerful than hitherto believed possible, were transmitted by the Cornell Aeronautical Laboratory under an Army Ordnance research contract.

Because of the extreme speed and unusual configuration of missiles, any radar contemplated for their detection must transmit a great deal more power than a corresponding radar used for the detection of aircraft. The tremendous peak power was radiated by a special microwave generator.

U. S. Scientists Describe Soviet Metallurgy Program

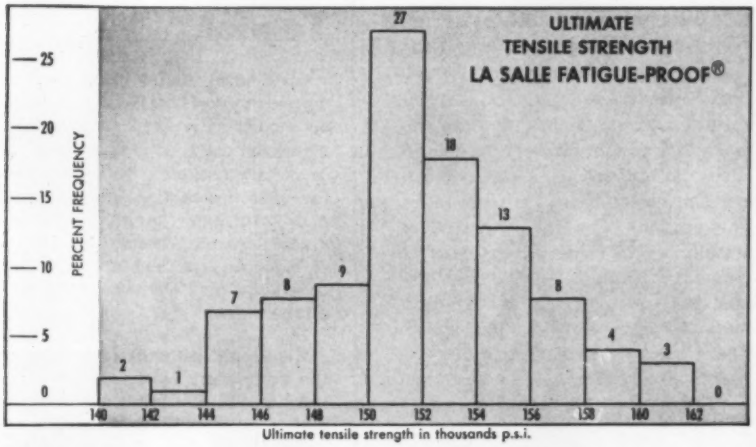
Point Out Abundance Of Men and Money

NEW YORK—There is no shortage of either money or manpower in Russia's metallurgical research program, but there are signs of a shortage of leaders, according to two American scientists who recently visited Russia. The Russians, however, appear confident that the shortage will be eliminated as a result of the large number of new scientists now being trained in this field.

The strengths and weaknesses of the Russian program were described by Dr. J. H. Hollomon and Dr. Walter R. Hibbard Jr., both of General Electric, in a paper presented before the AIME. Noting that in Russia "a few individuals hold several jobs each" with important responsibilities, the paper said, "These few leaders have a very large role in determining the direction of effort for a very large number of people and a very large budgetary commitment. The people . . . carrying out the research appear to have been well trained in their disciplines and thoroughly familiar with what they are doing. Many of the scientists (about 25 per cent) are women."

The paper stated that "Russian metallurgy has its greatest emphasis in fields related to the production of ferrous and basic nonferrous metals." Pointing to some of the differences between American and Russian approaches to metallurgical research, the scientists reported that one of these differences is "the appreciation in industrial, governmental and academic institutions of the needs of the nation and the tendency to concentrate research in certain areas to meet these needs.

"Workers in the laboratory of the Academy of Science and in the Baikov Institute are tremendously interested in vacuum and arc melt-



The above chart shows the range of ultimate tensile strength over a period of one year's production. Average value obtained is approximately 150,000 p.s.i.

"e.t.d."™ Process Applied to FATIGUE-PROOF™ Steel Bars Gives Added Strength, Greater Uniformity, Better Machinability

Guaranteed 140,000 p.s.i. minimum tensile... no heat treating necessary

Six important physical and mechanical properties, (1) a high strength level, (2) exceptional uniformity, (3) improved machinability, (4) wear resistance, (5) resistance to fatigue, and (6) dimensional stability, are desirable features of La Salle "FATIGUE-PROOF" steel bars, produced by the new "e.t.d." (Elevated Temperature Drawing) process.

Strength . . . "FATIGUE-PROOF" is a carbon steel bar which replaces both hot-rolled or cold-finished carbon and alloy heat-treatable steel bars. Production figures show hardnesses between Rc 30 and Rc 36 (with a minimum hardness guarantee of Rc 30). The guaranteed minimum tensile strength is 140,000 p.s.i. with a 150,000 p.s.i. average.

"FATIGUE-PROOF" is better than a heat treated bar because it is not quenched and tempered and so the problems frequently associated with quenching and tempering such as (1) quench cracks, (2) non-uniformity of section, (3) soft centers, and (4) heat treat distortion are eliminated. Costly secondary operations such as grinding, cleaning, and straightening are not necessary. Rejects are minimized.

Exceptional uniformity..."FATIGUE-PROOF" is remarkably uniform from bar to bar, end to end, size to size, and lot to lot. Design and production engineers can depend upon it being the same from day to day and job to job.

Individual processing of each bar plus the inherent good qualities and characteristics of the "e.t.d." process account for the excellent uniformity. Microstructures are uniformly pearlitic.

Improved machinability..."FATIGUE-PROOF", made by "e.t.d.", machines 50% to 100% faster than heat treated alloys, and 25% faster than annealed alloy steels. It machines with a very fine finish, and gives excellent tool life. These characteristics make it an ideal steel for production parts.

Wearability . . . Field applications such as gears, pinions, pins, and screws prove that "FATIGUE-PROOF" has good wear resistance. It resists galling and seizure, partly due to its hardness . . . and probably due to the anti-weld characteristics of its chemistry. Further, "FATIGUE-PROOF's" pearlitic structure appears to resist sliding wear better than a quenched and tempered structure of equal hardness.

Resistance to fatigue . . . The chief reason for the failure of highly stressed parts is fatigue. While part shape, unfavorable residual stresses, tool marks, gouges in highly stressed areas, and many other factors contribute to fatigue failure, most materials have also an inherent quality . . . endurance limit that is an indication of ability to resist fatigue.

"FATIGUE-PROOF" has this inherent quality to resist fatigue. Laboratory tests prove that fatigue properties are at least comparable to those of expensive heat treated steels of the same strength level. Numerous field tests, under severe operating conditions, have proved this to the satisfaction of many manufacturers.

Dimensional stability... "FATIGUE-PROOF" maintains a high degree of dimensional stability in machining because of its low order of residual stresses.

Details of the e.t.d." process . . . Elevated Temperature Drawing involves (1) the selection of bar chemistry, (2) the amount of reduction in cross-sectional area of the bar as it is drawn through a special die, and (3) a preselected elevated drawing temperature which will result in the desired final properties.

Although the "e.t.d." process was first announced early in 1957, it has been used in the production of "FATIGUE-PROOF" steel bars since September 1955. Four U.S. Patents (Nos. 2,767,835, -6, -7, and -8) were granted October 23, 1956, covering the "e.t.d." process – an exclusive development of La Salle Steel Company.

How manufacturers can obtain sample Fatigue-Proof steel bars for testing

LaSalle Steel Company has announced that samples of "FATIGUE-PROOF" steel bars, made by the "e.t.d." (Elevated Temperature Drawing) process, are available for test purposes on a no charge basis to manufacturers where it appears that "FATIGUE-PROOF" can help improve products and reduce production costs.

Applications for a sample bar are invited from manufacturers making parts from either hot-rolled or cold-finished carbon or alloy steel bars which require high tensile strength.

Interested manufacturers may write for a test sample by sending a blueprint or application details direct to LaSalle Steel Company, Advertising Department, P. O. Box 6800-A, Chicago 80, Ill.

"FATIGUE-PROOF" is also available from your steel distributor . . . write for his name.

Brochure tells story of Fatigue-Proof steel bars

"A New Material" is the title of a 24-page booklet which gives detailed information covering La Salle "FATIGUE-PROOF" steel bars made by the Elevated Temperature Drawing process.

The booklet presents the results of more than one year's tests of production samples and reports on eight application case studies. Copies available on request.

TM—Trademarks of La Salle Steel Company

La Salle STEEL CO.

1426 150th STREET
HAMMOND, INDIANA

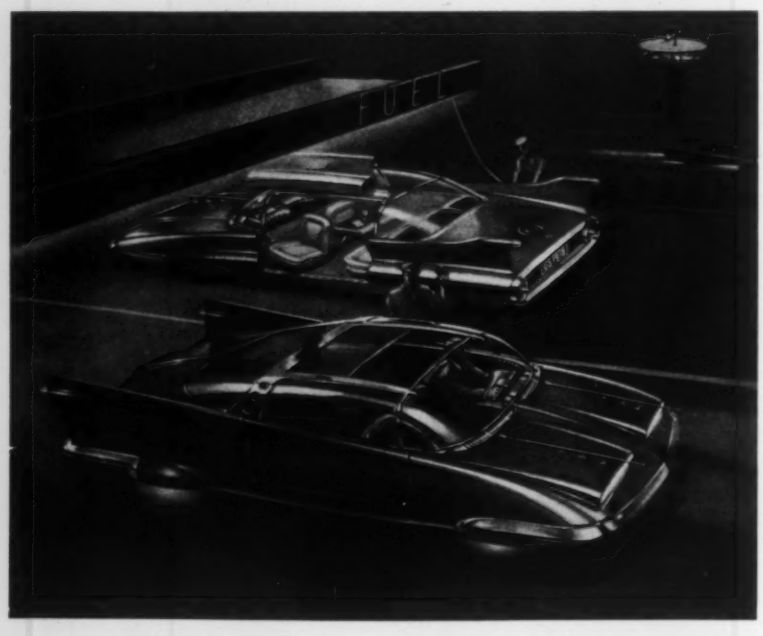
ing, not primarily as a means of studying scientific problems having to do with metals, but, . . . because of the interest of industry in high-temperature alloys generally." Dr. Hollomon and Dr. Hibbard were impressed with the great numbers of personnel involved. Moscow State University, for instance, was described as having 2000 faculty members and 1500 graduate students, many of them in research.

Commenting further, the paper said, "Their programs appear to be designed to use more people than ours. Once they decide to investigate a subject, they cover it very extensively and intensively, including many types of experiments and measurements on a systematic empirical basis . . . One of the big problems they face to go with this very large effort is the necessary leadership in planning and co-ordination of their research."

The authors described the Russians' system of disseminating scientific information as highly organized and effective.

"Possibly one of the most impressive Russian programs is their utilization of scientific information," the paper declared. "Scientists and engineers have a remarkable familiarity with the scientific literature of Russia, Western Europe and the United States. The student who is graduated in metallurgy is required to learn to translate English at the remarkable rate of 3000 units (approximately 500 words) per hour. Therefore, the scientists doing research in metallurgy, for the most part, can read English reasonably well and follow our literature in its original language. In addition, many can translate German or French.

"Russian and foreign literature is available to all these individuals through extensive libraries. The library at the Moscow State University contains five million volumes. At the Leningrad Polytechnic Institute there is a library of 1.5 million volumes plus 100 American and 100 Western European periodicals in the scientific fields. Thus the Russian scientist can get the American and English



RIDING ON AIR—at a recommended altitude of two feet—is featured by this new addition to the dream-car market. Propelled by ducted fans, the car could utilize existing turbine engines for power and existing tail fins for aerodynamic stability. Displayed at a recent Industrial Designers Institute meeting, this model has possibilities—the Army is experimenting with similar flying jeeps; may fly one this month.

Topics

Oil floating under water in submarine tankers very likely could be moved at a rate of 40 knots, compared with 17 knots possible in surface tankers. The speed factor, plus potential efficiency, cost, and probable design, will be studied by the Electric Boat Div. of General Dynamics Corp. under contract from the Maritime Administration.

• • •

Electronic baby sitter is part of the equipment of a new clinic in Germany. Microphones are installed in the ceiling of the infants' ward; when the sound of crying reaches a certain intensity, warning lights signal nurses.

• • •

World's most honest card game is one played at a mechanical table invented by a Canadian. Players do not touch their cards, but make them pop up by pressing buttons. Hands are screened except when they should be revealed to other players. The machine shuffles and deals. This spoilsport can be used for bridge games, and draw or stud poker.

• • •

Russians are in a flap—or hope to be—in small experimental ornithopters (planes with flapping wings). There is some question whether the planes will work, or whether flapping is strictly for the feathered comrades.

• • •

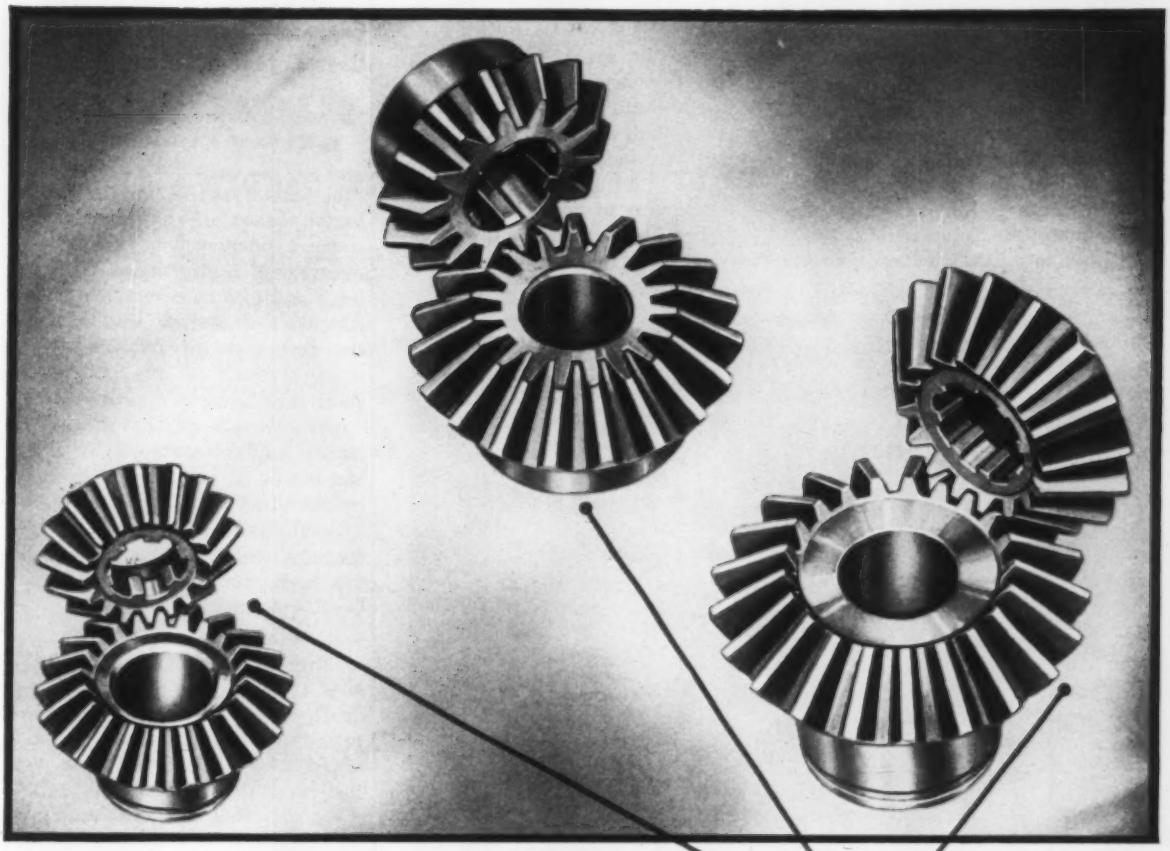
Brain on dates: An IBM computer has been fed data that enable it to give the historical highlights of every year since 4 B.C. The machine, which can answer in any of ten languages, will go to Belgium as part of the U.S. exhibit at the Brussels World's Fair.

• • •

Computer with a bedside manner may be common in the distant future. Facts about the body and mind of an ailing patient could be run through a computer to produce a diagnosis, according to Dr. Ralph W. Stacy of Ohio State University. Dr. Stacy foresees recording and storing of medical information. During a check-up, the computer would note any deviations from previous recordings.

• • •

Look cats—no feet are required to play the bass drum if a musician uses a newly patented, electric automatic drum-beating device. It is preset to use one or two drumsticks and plays slow single beats or faster double beats.



Shortest way to better production, smoother product performance: G.S. Bevels

FRACTIONAL HORSEPOWER GEARING

GEAR Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

Nobody argues with the old axiom, "Time is Money"—and it's more and more costly to have assembly operations interrupted or slowed down by ill-fitting or defective parts. G.S. customers (whose roster reads like a Blue Book of American industry) don't worry about such problems. They've learned that they can rely on famous G.S. precision manufacturing methods and rigid inspection systems for Small Gearing made *right*, every time—Gearing which meets demanding specifications, makes assembly smoother, gives efficient performance in product use.

Perhaps you use full-generated and hardened Straight Tooth Bevel Gears cut from alloy steels, like those illustrated (they're used in outboard motors). Perhaps you need Spiral Bevels or Zerols. Whatever your requirements for Bevel Gearing, including Helicals, Internals or other types, G.S. engineering and G.S. quality belong on your production team!

SEND FOR *G.S. technical data, free! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

42 Years of Specializing in Small Gearing!

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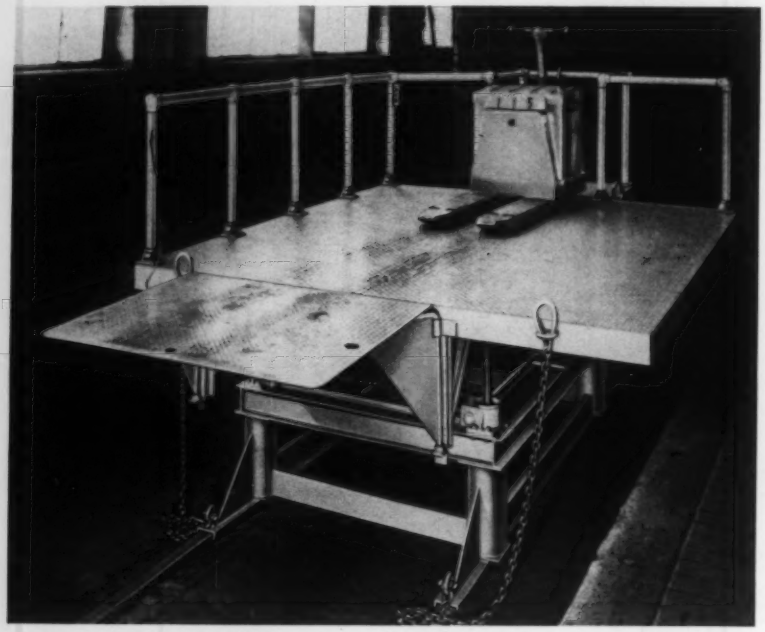
journals approximately six months after they are issued.

"Furthermore, there is a very large government organization for disseminating scientific information: the All-Union Institute for Scientific Information. Here, most of the important English works are translated into Russian and disseminated to the scientific workers. . .

"There is great incentive, in terms of money and prestige, for professors and scientists to write books on their specialties. . . . These books are inexpensive compared with books in the United States. The Academy of Science published 416,000 pages in 1955, including fifty journals."



PORTABLE LOADING DOCK with variable-height platform adjusts to any truck bed level (36 in. to 59 in.), and eliminates use of ramps. Platform is 10 ft by 12 ft exclusive of extensions; load capacity is 10 tons. Lift speed, 13 in. per minute, is controlled by a "start-stop-inch" button mounted on the guard rail. A 5-hp, 220-440 v crane hoist motor provides power. Power transmission—through roller chain, worm gear, and screw—is applied to each corner of the platform to assure no-tip, four-point support. Builder: Hamilton Tool Co.

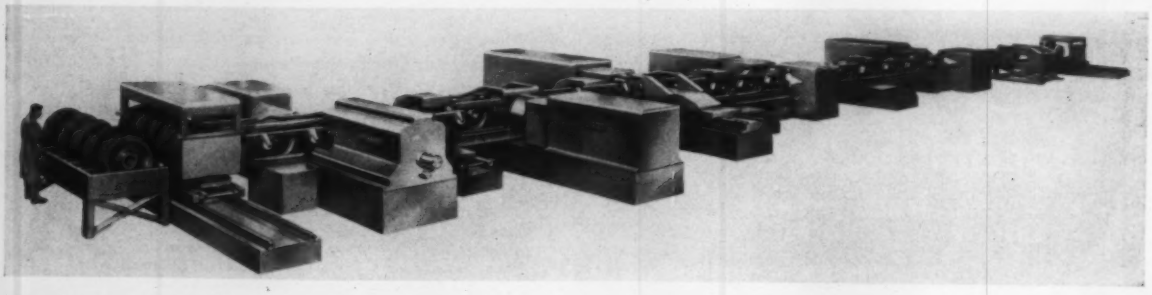
Compact Cavitation Detector Uses Cryogenics Principle

Checks Missile Fuel Systems To Prevent Explosions

PHOENIX, ARIZ.—A cavitation detector based on a recently discovered phenomenon in the cryogenic and hydrocarbon field detects and locates cavitation in any complex flow system. Cavitation or the formation of bubbles occurs when pressure at any point in a fluid flow system approaches the vapor pressure of that fluid. In missile oxidizer systems, cavitation can result in explosions when the oxidizer-fuel ratio has been upset by bubbles in the system. Extremely small, the new detector has been produced by the Garrett Corp.'s AiResearch Mfg. Div.

It determines any tendency of oxidizer and fuel systems of missiles to cavitate while undergoing development, in the test stand, or prior to or in flight. Another missile application is detection of cavitation when booster-rocket oxidizer or fuel sources approach depletion, and pressurizing gas enters the oxidizer or fuel systems. Maximum fuel usage with greater missile range can be assured and a balanced oxidizer-fuel ratio can be maintained before booster rockets are released.

The detector consists of a sensing mechanism and controller composed of electrical circuits. It has recorded bubbles 0.05 in. diam in a 6-in. line. Detection signals can be transmitted to an oscilloscope or a telemetering transmitter.



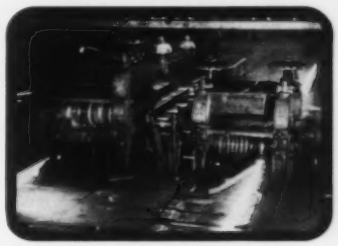
ONE WHEEL EVERY 90 SEC will be completely machined on the world's first automated, five-machine transfer line for railroad car wheels, now being built by Kearney & Trecker Corp. Each of the five machines is a separate machine tool, interlocked with load, unload, and inspection stations to operate as one machine which will load, rough bore, face, turn, inspect, and unload the workpiece. The control system allows the entire line to be operated as a single unit or enables each machine to be operated individually.

ANOTHER COPPERWELD SERVICE

complete cold finishing facilities

Electric Furnace.

Ingot entering 35" Blooming Mill.



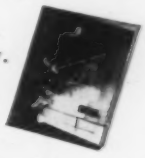
12" Bar Mill in operation.

From electric furnaces to cold finishing—close metallurgical control is the secret of the uniform quality of Aristoloy blooms, billets and bars.

Starting with select raw materials, and exercising special care in melting and teeming operations, Copperweld produces the special Aristoloy ingot. From here, conditioning, rolling, thermal treatment, and cold drawing are under the same careful scrutiny . . . the same control. The result—steels of uniform quality bearing the name Aristoloy!

Cold finished Aristoloy as well as hot rolled products are available in standard A.I.S.I. analyses, including leaded—call your Copperweld Field Metallurgist for help in selecting the best grade for your job.

New Leaded Steel Catalog now available. Write for your copy today.



Cold Drawing.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY • Steel Division
4017 Mahoning Avenue • WARREN, OHIO

EXPORT: Copperweld Steel International Co.
225 Broadway, New York 7, N.Y.

AMERICAN STEEL WAREHOUSE ASS'N.

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WALKIE-WORKLIFTER, a newly developed lift, elevates both the operator and his workload, besides transporting. Made by the Economy Engineering Co., the unit enables the operator to work at shelf heights.

Ceramic Electron Tube Fills Vital Radar Need

NEW YORK—The need for increased power in radar equipment, necessary for detection of supersonic manned aircraft and ballistic missiles, has resulted in a new concept in the hydrogen thyratron —a pulse-circuit switching tube and vital radar component. The new design: Ceramic hydrogen thyratron with external anode and grid elements.

According to G-E researchers H. N. Price and A. W. Coolidge, switch tube development has not kept pace with the advancements in the high-frequency oscillator tubes, and present hydrogen thyratrons do not readily lend themselves to extension beyond present power levels.

The new design provides greater reservoir ranges at present power levels and acceptable ranges at greatly extended power levels, they reported.

In addition, the ceramic tube has high mechanical strength, rigidity, and improved shock and vibration resistance. These characteristics are especially important, since the new tubes will be used primarily in military electronics.

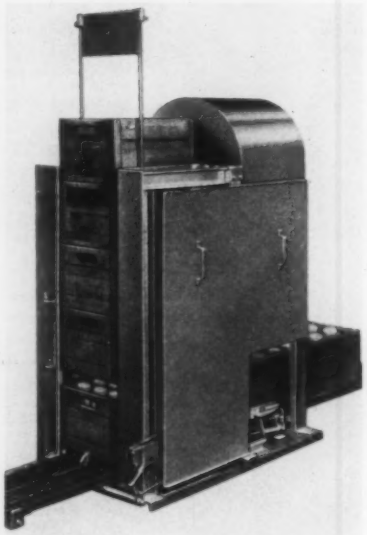
See Full Representation At Design Show-Conference

NEW YORK—Virtually every major company in the country will be represented among visitors at the Design Engineering Show when it opens on April 14 for a four-day run, predict its producers. Advance registrations and inquiries indicate that 20,000 of the nation's design engineers and product development executives will be on hand to inspect the exhibits of 410 companies, according to Clapp & Poliak Inc., exposition management firm which produces the show.

The show, which was held previously in Philadelphia and New York, will be produced in Chicago for the first time. Its rate of growth has been unprecedented. What was a brand new show in 1956 will be one of the largest annual industrial expositions held in the U. S. during 1958. Exhibits covering an area of 125,000 sq ft will be four times the size of the first show, 50 per cent larger than the second. The products and displays are valued at more than $10 million, with about 12,000 separate products on exhibit.

More than 4000 technical specialists will be on hand to answer visitors' questions. Visitors wil represent companies whose products range from everyday household items to earth satellites and atomic reactors. Exhibits will include mechanical, electrical, electronic, hydraulic, and pneumatic components; power-transmission equipment; materials; fasteners and adhesives; finishes and coatings.

The four-day Design Engineering Conference, conducted by the machine design division of the American Society of Mechanical Engineers, will be held concurrently with the show. Systems for improving exchange of information among engineers and methods for "Putting the Design into Production" will highlight the session.



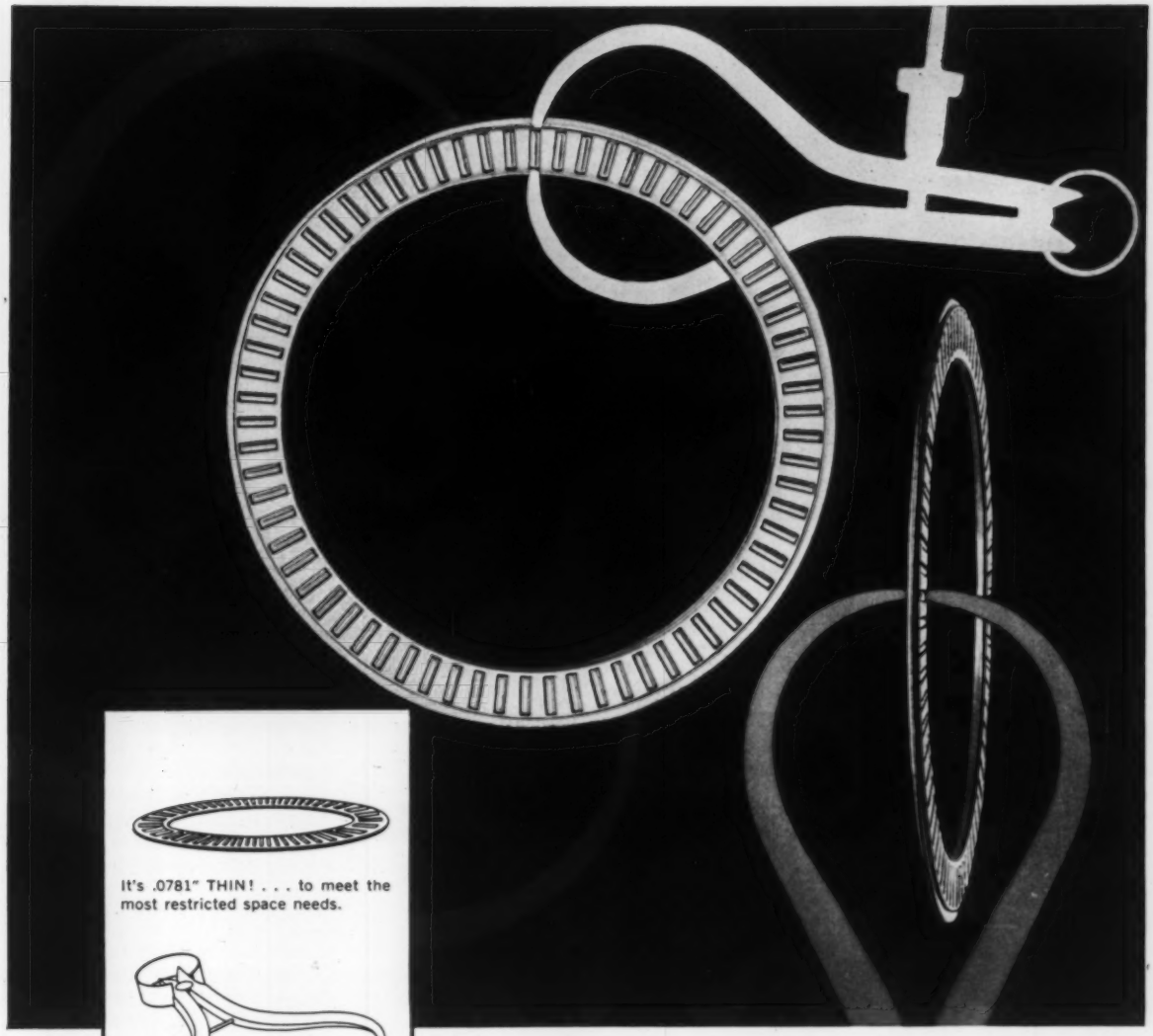
STARTING AT THE BOTTOM is how this case stacking machine stacks cases. Completely mechanical, it can be preset for case sizes, and stacks wooden, metal, or wire cases in three to seven-high stacks. Powered by a ¾ hp, 220-volt motor, Ezee-Up stacker is manufactured by Lathrop-Paulson Co.

Portable Nuclear Powerplants Await Seal Research

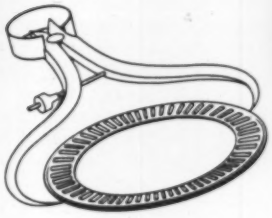
COLUMBUS, OHIO—Rotating shaft seals to meet the unusual heat and pressure demands of a gas-turbine nuclear powerplant, are subjects of research at Battelle Memorial Institute.

Army Engineers' requirements demand that the seal work efficiently on a turbine-compressor unit operating at 25,000 rpm, at a peak pressure of 1000 psi, and at peak temperatures of about 1350 F. Moreover, the seal must be able to keep leakage of the helium working fluid so slight that it will not be necessary to add helium to the circulatory system for a matter of months.

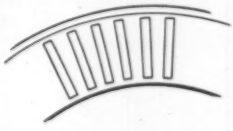
Engineers at the Army's Fort Belvoir Laboratories explain that practical solution to the rotating seal problem is necessary before a working model of a turbine can be built. Over-all aim of the project: To develop small nuclear powerplants that can be used in the field for a variety of purposes.



It's .0781" THIN! . . . to meet the most restricted space needs.



OD is much smaller, for given shaft size, than other types of thrust bearings.



Needle-proportioned rollers provide large contact area in minimum cross section.

By Every Measure . . . Ideal For Compact Thrust Applications

Whether you gauge its value in compactness, high anti-friction efficiency, high thrust capacity, or low unit cost, you will find the new Torrington Needle Thrust Bearing measures up ideally to your needs.

This needle-type bearing is designed specifically for thrust loads in restricted space. It may run directly on adjacent hardened and ground surfaces or on standard thrust races. Used alone, or in combination with Torrington radial type Needle Bearings, the Needle Thrust Bearing finds wide use in many applications including steering gears, hydraulic pumps, tractor bolsters, bevel and worm gear boxes, governors, outboard motors, 2-cycle engines, washing machines, power tools, torque converters, and automatic transmissions.

For engineering information and assistance in design, please call upon the services of Torrington's Engineering Department. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

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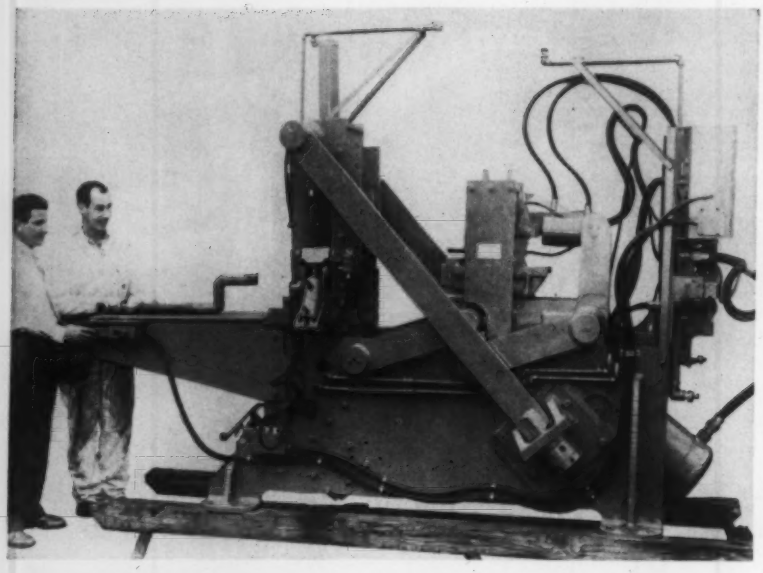


AXLE-BENDER makes offsets in steel bars up to 3½ in. in diam. Used in the manufacture of truck and house trailers, the 12,000-lb axle-bending machine was designed and built by Allied Engineering & Production Corp. The bender's design includes built-in automatic cycling and safety controls.

Stop Engineering Waste, Society Head Urges

EAST LANSING, MICH.—Engineering waste must be stopped. . . "greatly improved utilization of engineering talent is the only solution to the problem posed by the coming drop in the male labor force which will result in 700,000 fewer men aged 25-34 in 1965 than we have right now," the president of the National Society of Professional Engineers said here recently. Garvin H. Dyer told the National Society's board of directors that the "drop in births during the depression years of the 30s will definitely be reflected in a drop in the number of men in the younger age brackets by 1965."

The head of the 43,000-member engineering group pointed out that "census figures indicate the futility of trying to solve our critical manpower problems by merely increasing the number of engineering graduates." Speaking at the group's spring meeting, he urged that industry, government, and educational leaders "concentrate on better utilization of the engineers we do have, rather than on sputnik-inspired crash programs to increase the number of engineering students."

He cited recent studies of engineers employed in industry which concluded that engineering talent was wasted by being used at a level below that at which it is capable of performing.

Will Hold Seminar on New American Drawing Standard

URBANA, ILL.—A seminar on "The New American Drawing Standard" will be conducted by the General Engineering Dept. of the University of Illinois in co-operation with the local sections of several engineering societies. This meeting, scheduled for April 29 and 30, is the outgrowth of the American-British-Canadian Conference on Unification of Drafting Standards held last October in Toronto.

Papers to be presented include, *True Position Dimensioning* by T. J. O'Connor of Bell Telephone Laboratories, *Tolerancing of Form* by G. Noble of Dominion Engineering Co., *Maximum Material Concept Applied to Tolerancing of Form and Position* by P. G. Belitsos of General Electric Co., and *Proposed Symbols for Tolerancing of Form and Position* by S. Miller of the U. S. Dept. of Defense.

Defense Digest

Two Snarks a month is the production schedule for the only operational 5500-mi missile in the U. S. arsenal. Recent tests have further confirmed the missile's deadly accuracy. Staunch supporters, including many Air Force officials, claim that a squadron of Snarks sneaking in on target at treetop level would make a "sizeable" penetration in enemy defenses. Those opposed say radar systems are fast becoming too sophisticated for subsonic missiles. Meanwhile, Snark is expected to be the major "transitional" weapon for 3 or 4 years, and Northrop is reportedly building a supersonic version.

• • •

Navy's Polaris is running more than a year ahead of top priority development schedule; will be ready in 1960. "Our greatest fear now is overconfidence" says Rear Admiral W. F. Raborn, Navy's chief of special projects. Free-roaming nuclear submarines with multi-Polaris armament will be the Navy's bid in strategic warfare. Contracts for the submarines were placed last month. Says Raborn, "By carrying the launching site to sea, it will take the bull's-eye off our country and force the enemy to concentrate his countermeasures on the seven seas."

• • •

Minuteman missile system—Air Force entry in solid-fuel missilery—promises to be the biggest project in the entire, ever-growing missile business. Minuteman will reportedly combine a short-range (tactical) missile, an IRBM, and an ICBM all in one package. As an ICBM, stationed in the U. S., its launching site will be a concrete-lined hole in the ground. Doing away with liquid oxygen, countdowns, and faulty fuel pumps, 50 Minutemen in 50 holes would wait silently and secretly for an operator in a remote station to press the firing button. Operational date: 1962.

• • •

First all-supersonic bomber will be North American's B-70 (formerly WS-110A). Convair's B-58, currently the fastest long-range bomber in the air, spurts to supersonic speeds over target areas or in taking evasive action. B-70 will cruise all the way to target and back at 2000 to 3000 mph. Operating altitude: 70,000 ft.

Tube Vies for Size With Shirt Button

Operates at Temperatures Of 900 to 1500 F

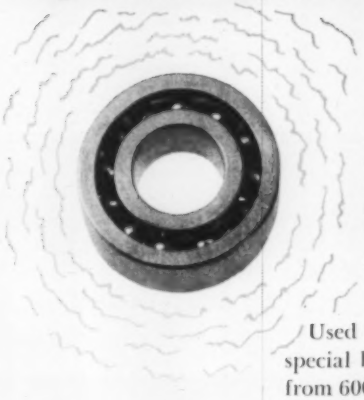
SCHENECTADY, N. Y.—An electron tube not much larger than a shirt button and capable of operating at temperatures from 900 to 1500 F is at work in the laboratory. The experimental models now being evaluated at the General Electric Research Laboratory are shaped like flat discs and measure only ¼ in. diam and ⅛ in. thick.

Their extremely small size is due in part to the fact that they contain no heater, all the heat necessary being provided by their high-temperature environment. The design is still in the laboratory stage and no tubes are commercially available at this time.

The new design is the latest in a series of developments that have brought the electron tube down to the size of its competitor, the transistor. At the same time, the ability of the new tubes to withstand high temperatures makes possible extensive weight reductions, since heavy, bulky cooling equipment becomes unnecessary.

The new tube is considerably smaller, however, than any shown previously. Like its predecessors, it is constructed of layers of titanium and a special ceramic.

Operates at 1100° F.!



This 7/8"-OD bearing carries a 150-lb. load with a slow oscillatory motion at temperatures to 1100°F. while subjected to vibration and severe corrosion conditions. Other special high-temperature bearings by ITI meet even tougher requirements.

Used in jet engine components, this special bearing operates at temperatures from 600° to 1100°F. under severe oxidation and corrosion conditions, for a minimum service life of 300 hours. Balls and races are special cobalt-chromium-nickel alloy for hot hardness and durability.

As with all high-temperature bearings, success depends largely on careful attention to internal geometry and other minute detail, based on experience and bearing engineering know-how. At high temperatures, available materials that have the required hardness, wear and corrosion properties are frequently marginal with regard to load-carrying and fatigue characteristics, especially when operating temperatures exceed ceilings of available lubricants.

We have designed and manufactured high-temperature bearings to meet a wide variety of requirements as to speed, load, temperature and service life.

IF YOU need anti-friction bearings of *special shape, size, heat resistance, corrosion resistance, low torque, ultra precision, non-magnetic properties, or other unusual characteristics,* we can supply them — designed and built to your specific requirements. We invite your inquiries.

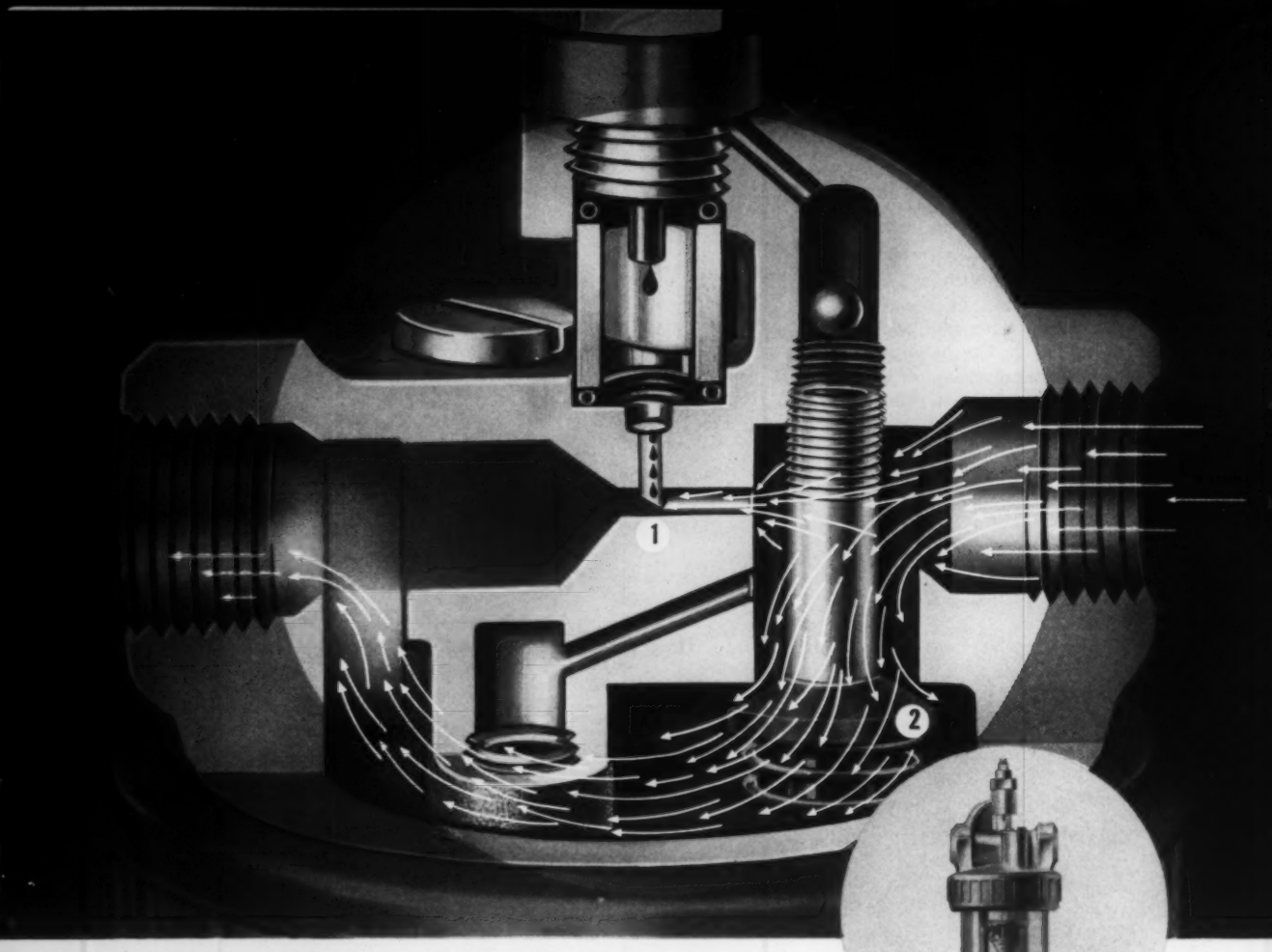
NEW 24-PAGE BEARINGS BULLETIN tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*

INDUSTRIAL TECTONICS, Inc.

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3690 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA



Wide range performance made possible **in a single unit** because ❶ exclusive small venturi section provides efficient lubrication at air flow rates as low as 1 CFM, ❷ exclusive automatic bypass valve maintains lubrication at high air flow rates with negligible pressure drop.

Now! EFFICIENT pneumatic equipment LUBRICATION AT ALL AIR FLOW RATES

Enough oil — but not too much. A fine mist at *any* flow rate . . . ultra-fine, enduring atomization that assures *efficient* lubrication. Tools, chucks, cylinders, other air equipment function smoothly at *any* speed when lubricated by Watts air line lubricators.

WATTS FILTERS — exclusive "TORNADO ACTION" provides really clean dry air

Filter life is extended by extreme centrifugal force which spirals dirt and moisture particles downward into "quiet zone", leaving only a minute percentage of the finest and lightest particles to be trapped by the filter cone.

You get optimum efficiency from these advanced-design units because Watts has *specialized* in protection and control devices since 1875. Exclusive features and precision construction assure reliable, lowest-cost performance.

WATTS REGULATORS — sensitive "Aspirator Action" maintains more uniform pressure

Aspirator acts directly on diaphragm giving instant compensation for fluctuating load demands . . . provides precise control and stabilizes pressures reaching individual pieces of equipment.

Write for free technical catalog. Charts, diagrams, performance data enable you to specify the right Watts pneumatic equipment right on the spot!

WATTS

FILTERS
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YOUR SAFE SPECIFICATION

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Reader Information Service

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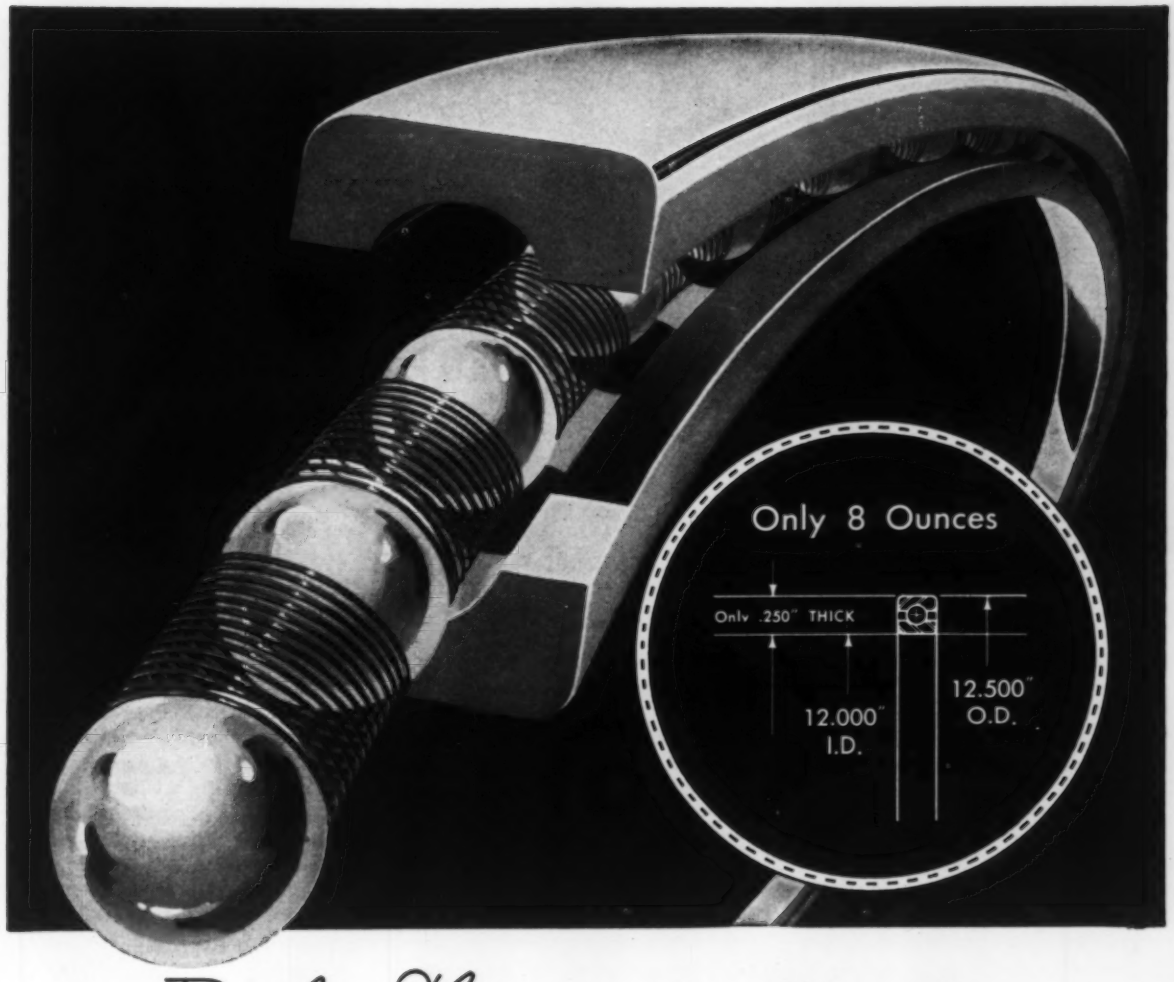

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Circle 413 on Page 19

High temperature . . .
Slow response time . . .
Cosmic radiation . . .

and hippopotamuses on the instrument panel are some of the problems generated by sending a

MAN INTO SPACE

MAN IS PROBING the borders of space. And he is finding that problems of existence in space, although profound, are not impossible.

Most recent step was Maj. David Simons' Project Man High balloon trip to 102,000 ft (19 miles) for 32 hr in August, 1957. Next trip will probably be this summer.

Next year may see USAF Capt. Iven C. Kincheloe Jr. take the North American X-15 rocket research aircraft 100 miles up—and possibly two to three times this distance—at speeds of Mach 5-7.

What does man face on these flights—and beyond into space? Many of the questions are known today, and a few of the answers.

Problems of Man in Space: Man is a highly restricted creature capable of existing for extended periods only within a temperature range of −90 to 136 F and air pressures from perhaps 5 to 25 psia. He needs oxygen, and can't stand more than about 3 per cent carbon dioxide in his breathing air. His response time is on the order of 10^3-10^4 slower than the instruments he controls. And he is subject to emotional and psychological quirks than can affect his performance in space.

These limitations help define the probable biggest design bugaboo for air and space craft of the future—man himself.

The problem can be broken down into two regions: High-speed flight through the atmosphere, and flight through space. Each of these can be considered in two aspects: "Normal" flight, and emergency conditions. Not all problem areas will be discussed here. Those relating to emergency protection, for instance, get quite detailed, and much work has been done. The main attempt will be to sketch in the "high-stress" areas, where space travel poses unusual demands even under "normal" flight.

Acceleration and Deceleration: Effects of acceleration have been thoroughly studied, and limits are reasonably well known. In a sitting position, man can tolerate 2 or 3-g accelerations without harm. At 4 g, vision at edges of the eyes is gone. At 5 g, central vision fades and muscles sag. At +6 g, complete blackout occurs as blood leaves head or, at −6 g, redout hits as blood is forced upward. At +6 g, a sitting pilot would have a difficult time lifting his arm or raising his head. At −6 g, he cannot move his position or eyes.

Negative acceleration, by the way, is more damaging than positive; there is a time effect that can produce damage even at a steady −3 g. Countermeasures are suits and devices that provide pressure on critical body areas.

Supine or prone positions also help to withstand acceleration forces. In the supine position (face up), normal, healthy adults have been subjected to 15 g accelerations for 5 seconds. In the prone (face down) or supine positions, forces of 7 g for 10 minutes or more, or forces of 10 g for 100 seconds, can be tolerated. These acceleration forces are within the range for flight to an orbit and beyond.

Weightlessness: Zero gravity, which occurs as a satellite orbits around the earth or space ship goes into "free flight," was at first thought to be a serious problem. Now, it seems, weightlessness will be an inconvenience, but perhaps can be licked.

Studies by Dr. Siegfried Gerathewohl have shown that about one-half the people experiencing zero gravity either showed no symptoms or actually enjoyed the experience. One-third were affected by gastrointestinal complaints.

Getting accustomed to weightlessness seems to be one big problem. About 30 ballistic dives were made by Scott Crossfield, former NACA pilot who was the first man to fly at Mach 2 (he's scheduled to make contractor flight tests of the X-15 for North American). In a ballistic dive the plane is first dived, then pulled up into a ballistic curve that pro-

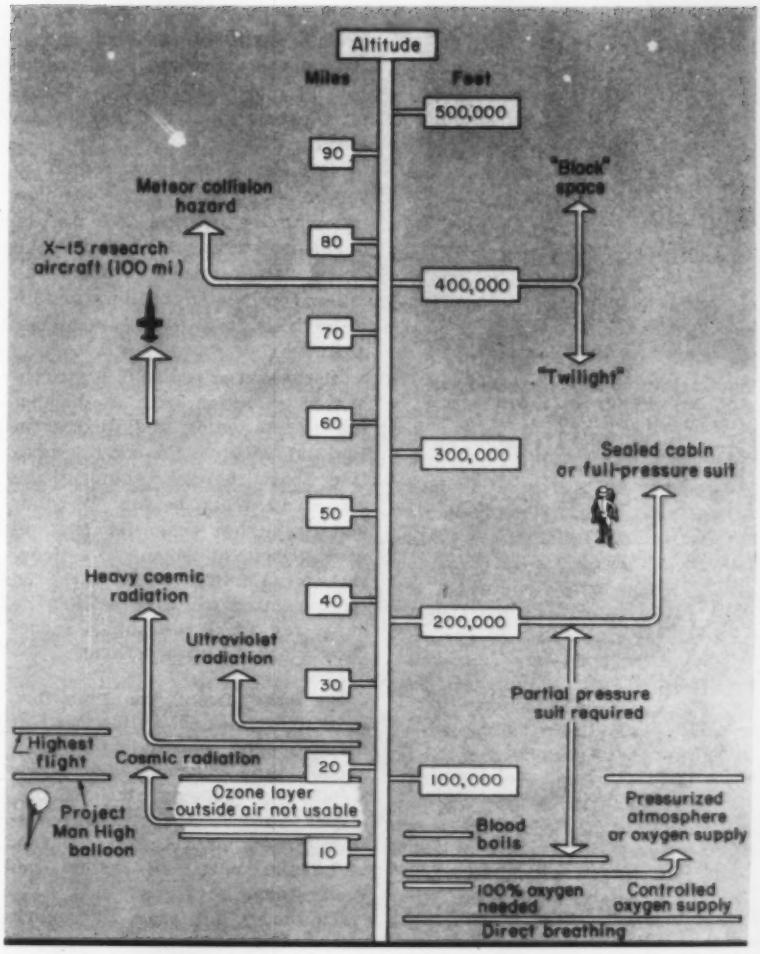
duces zero gravity. Crossfield reported feeling confused for the first five times; after that, he had complete control of the aircraft by visual reference.

For long periods of time, effects of weightlessness are still unknown. Perhaps 1 minute of weightless flight is the longest that has been achieved by the ballistic dive method. It is reported that X-15 will be able to achieve 5 minutes of weightless flight—still a short period.

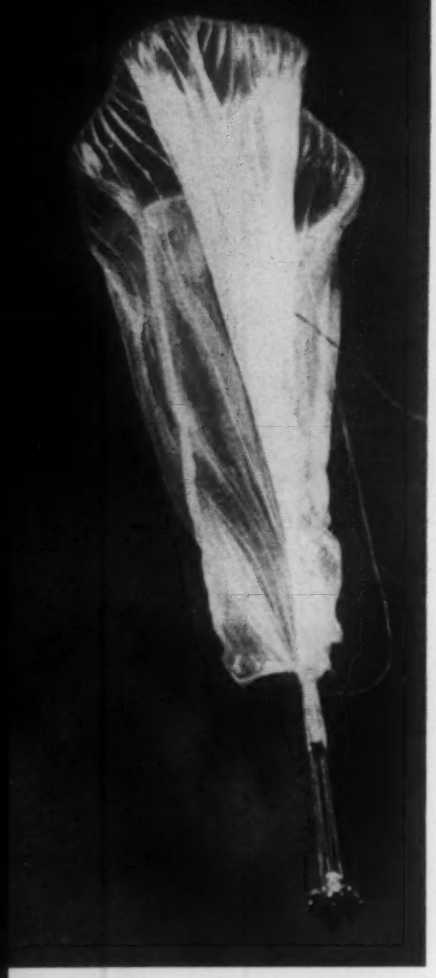
Zero gravity involves loss of the personal orientation involving the semicircular canals of the inner ear. This produces a sense of falling which can induce fatigue and apprehension reactions. On short flights, training can overcome this reaction, since visual senses can be substituted. No-one yet knows if this psychological factor will be important on long flights.

Temperature and Heat: Man exists on this earth in ambient temperature extremes from − 90 F to + 136.4 F (known records). But man's own body temperature range is much smaller—from about 86 F to 110 F. Below 86 F, he loses consciousness; above 110 F, he dies.

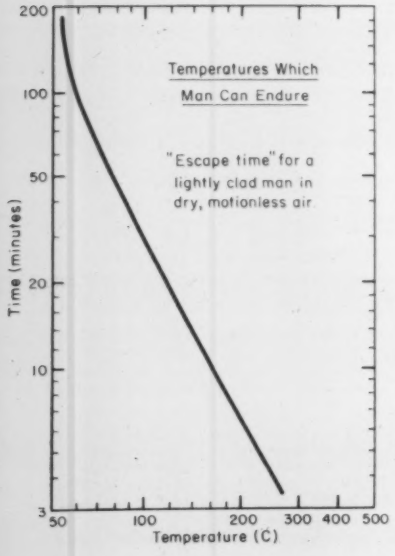
The major problem is how to move a high-speed vehicle through the heat-producing friction of air—



Altitudes where man runs into trouble in his flight to outer space



Project Man High balloon and capsule, in which Maj. David Simons went to 102,000 ft for 32 hr



the so-called "thermal thicket." Short exposures to relatively high temperatures are possible—for example, man can withstand exposures of 400 F for 10 seconds. But pain receptors function at 44.8 C (113 F), which is the absolute continuous upper limit.

Leading-edge and nose temperatures of high-speed aircraft may go to several thousand degrees fahrenheit. The exact upper limit depends on many factors— shape of the surface, conductivity of its material, radiation emissivity, and so on. Temperatures might be held to 2000 to 4000 F by certain designs. But even higher temperatures may be experienced before the thermal thicket is hurdled.

Luckily, these are "nose area" temperatures—n o t temperatures further back on the flight structures where the crew compartment is usually located. Here, structure temperatures are considerably lower. For example, in Mach-6 flight (about 4500 mph), airframe temperatures would probably be under 1000 F. This is approximately the condition to be faced in the X-15.

Methods of enabling a man to survive include advanced air-conditioning techniques and use of double-wall structures in which the inner wall is insulated from the outer (perhaps by boiling water; water boils at 70 to 80 F at higher altitudes).

In space, the problem is strictly one of radiation balance—balancing the incoming radiation from the sun with "black-body" radiation from the spaceship on the side away from the sun. Wernher von Braun has suggested that an arrangement analogous to a Venetian blind might work, with the blind painted white to reflect the sun's rays and the ship's underbody black to absorb them.

Response Time: The fact that most underlines the helplessness of man at high speeds is his slow response time. Time required for a pilot to perceive an oncoming object, refocus his eyes for distinct vision, arrive at a decision, and take muscular action can easily range to 2½ seconds.

This may not seem like much time. But it is sufficient that two X-15s travelling at Mach 5 on a head-on course and guided by pilots with 20/20 vision adequate to 1 minute of arc would *always* crash. The pilots simply could not react fast enough to take evasive action.

Another way to look at it is to assume two manned, orbiting satellites, each travelling toward the other at 18,000 mph. One would have to be over 40 ft in diameter for the pilot of the other to avoid a collision.

For this reason, all operations which must be timed exactly will have to be handled automatically —the pilot is restricted to "command" signals and functions which are not time-dependent.

Air Supply: Man needs oxygen—about 1 cu ft per hr—and he needs it at a minimum pressure. Carbon dioxide in his atmosphere must be held below 3 per cent. Water vapor and any noxious fumes must be removed.

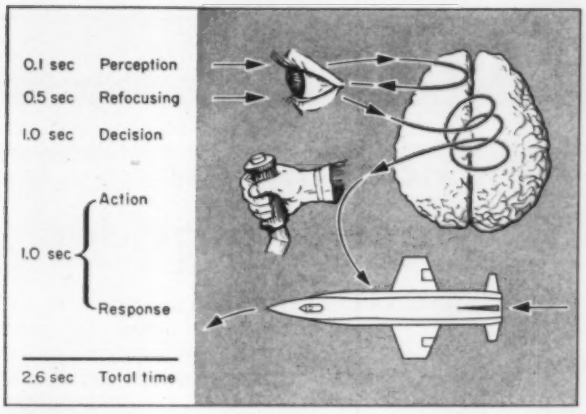
Oxygen at sea level has a partial pressure of 3.1 psi. Theoretically, a 100 per cent oxygen at 3.1 psi should satisfy man's breathing requirements. Although this pressure is sufficient for some humans, it is probably not high enough for all.

A pressure of about 5 psi (1/3 atmosphere) seems to be the minimum sufficient. But, since oxygen partial pressure must be maintained at about sea-level values, an increment of 1.9 psi must be supplied by another gas.

In air, this gas is nitrogen. Nitrogen, however, is quite soluble in the blood and tissues. Sudden decompression releases bubbles in the body tissues causing "bends" or "chokes." Helium is only about one-fifth as soluble as nitrogen, and would probably be used as the second gas.

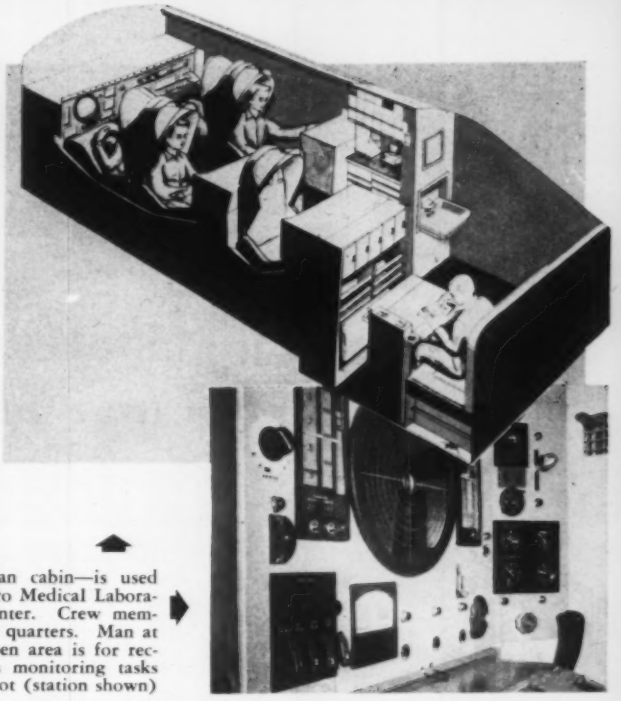
Carbon dioxide must be removed. Although maximum concentrations of 3 per cent at atmospheric pressure may be tolerable (the maximum permitted in Major Simons' Man High flight) concentrations of below 1 per cent would be necessary for extended periods.

In an open system for supplying oxygen, carbon dioxide removal is no problem. However, an open system is wasteful, since man uses only about 5 per cent of the air he breathes.



Response time for a pilot can be a serious problem

Slowness of man's response



Space cabin—a mockup of a five-man cabin—is used for psychological studies by USAF Aero Medical Laboratory at Wright Air Development Center. Crew members spend five days confined in close quarters. Man at right is sitting on sleeping couch; open area is for recreation and sleeping. Each man has monitoring tasks to perform during the "flights." Copilot (station shown) has two such monitoring tasks

MAN INTO SPACE

So a closed system, in which carbon dioxide and water vapor are removed, is a necessity for any extended flight. Methods suggested for removing carbon dioxide range from use of lithium hydroxide (the method used on Man High), to growing plants or algae. Water vapor removal would undoubtedly be by condensation.

These considerations strongly imply the use of a sealed cabin with its own stored atmosphere—an absolute necessity on space flights. Pressure could be maintained at atmospheric (14.7 psi) fairly easily, although lower pressures might be possible.

Cosmic Radiation: Above 120,000 ft, man is exposed to primary cosmic radiation, mainly protons with nuclei of helium and other elements. These high-energy particles eventually strike others, creating secondary particles. Effects of this radiation on man may be like those of other known radiations such as x-rays and gamma radiation, although there is some reason to think that the body is "transparent" to primary particles. Cosmic rays cannot be stopped with less than about 3 ft of lead, and even that will not stop the more powerful radiations.

Whether man can exist for lengthy periods in this bombardment is still debated. Estimates of tolerance levels range all the way from 15 hr per day to a full year or more of constant exposure. Longest exposure to date is Maj. Simons' 32-hr Man High balloon trip.

Psychological Problems: Last, and perhaps most important, problem is the psychology of man. The psychological implications of weightlessness have already been mentioned, and problems of diurnal necessities, overconcentration, boredom, isolation, and confinement can be added. Even these are a doubtful list, for psychology of space can only be thoroughly studied in space. But preliminary studies have revealed some interesting, and amusing, sidelights.

One fact, for example, is that the day-night cycle of sleep and wakefulness cannot be escaped. "We are stuck with the diurnal rhythm," said G. T. Hauty of USAF's School of Aviation Medicine in a recent IAS paper. "It can be shifted, reversed, lengthened and shortened to some extent, but it cannot be broken or eliminated." Hence, the day-night cycle must be simulated.

Secondly, concentration on one task for long periods, or sharp reduction of "background" stimulation (such as might occur in a confined one-man cabin) can induce hallucinations. Hauty cites reports ranging from "the instrument panel kept melting and dripping on the floor" to "on several occasions the bank indicator showed a hippopotamus smiling at me."

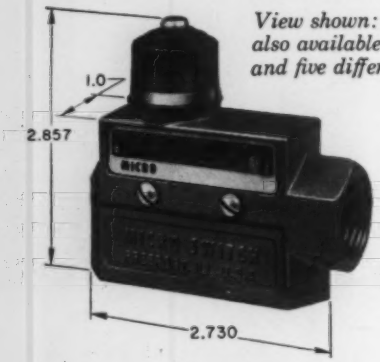
Confinement and isolation of single or multiple-man crews can also breed problems. These are currently being studied by simulation. At Lockheed and Wright-Patterson AF Base, five-man crews are confined for five days under simulated conditions. Another test at the School of Aviation Medicine at Randolph Air Force Base in February involved week-long confinement of one man in a sitting and semireclining position. Airman Donald G. Farrell completed the "trip" without ill effects.

Not the End: Many facets of existence in high-speed and space flight have not been mentioned: Food, disposal of waste, re-entry methods into the atmosphere, and amount of necessary equipment, to name only a few. They are slowly being solved. Perhaps, in ten years or so, we'll really have a man on, rather than in, the moon.

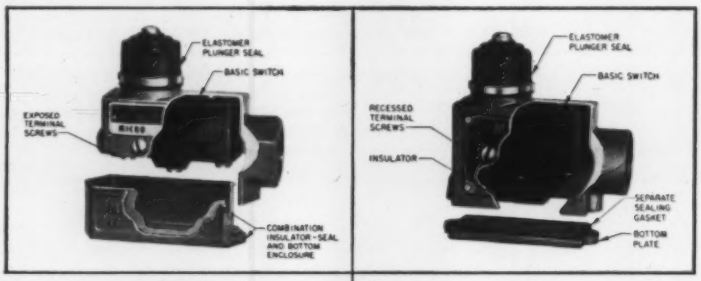
—R. L. STEDFELD

MICRO SWITCH Precision Switches

NEW! . . . A new housing for the widely used "E" and "V" series provides Easier Installation . . . a Better Seal . . . and Better Insulation



View shown: side mounting; also available with bottom mounting and five different actuator designs.



NEW OLD

Compare these two cut-away views. Note how terminal screws in the new "E6" Series project from the bottom of the top portion of the housing; how the insulator and seal are one moulded neoprene piece, cemented into lower portion of the housing.

This new housing replaces the one formerly used in the "E" and "V" Series and is known as the "E6" and "V6" Series. The new series is interchangeable with the old series.

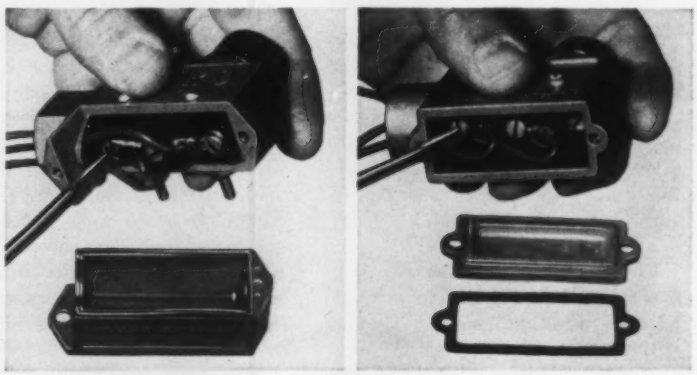
The new "E6" and "V6" have these outstanding advantages:

Easier Installation. Terminal screws now project from top portion of housing instead of being recessed in a cavity, thereby making easier installation.

Improved Insulation. A one-piece moulded neoprene insulator-seal, cemented into lower portion of housing replaces the separate, wrap-around Fiberglas insulator and separate gasket.

Rugged–Heavier Walls. The new, two piece housing has heavier walls—a hex-shaped conduit hub instead of round. A much cleaner, stronger design.

Interchangeable with old series. Dimensionally the same as old series—same mounting holes, same width, height and depth. Compact—fewer parts.



NEW OLD

The new series design can be installed in jig-time. No deep cavity in which to fumble with a screw-driver, no fold-in insulator, no jiggling with a separate sealing gasket.

For complete details of this new series write for Data Sheet No. 145.

The two word name "MICRO SWITCH" is NOT a generic term. It is the name of a division of Minneapolis-Honeywell Regulator Company.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

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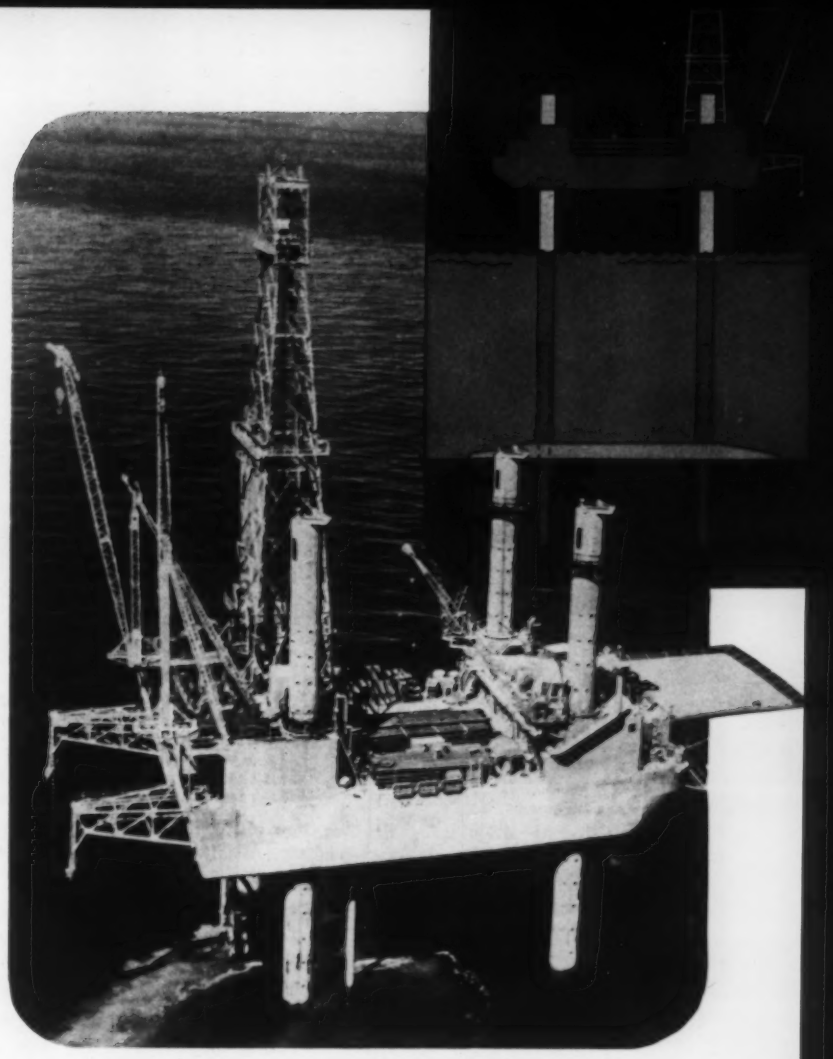
First in Precision Switching

Circle 414 on Page 19



Mr. Gus II:

World's Largest Off-Shore Drilling Barge

MR. GUS II sits in the Gulf of Mexico. Raised above the water on four stilt-like legs, he pokes his snout into the sea bottom to find oil. He has successfully ridden out the onslaught of two terrible females — hurricanes Bertha and Esther.

Built at a cost of $6.5 million by Bethlehem Steel for C. G. Glasscock Drilling Co., the 9000-ton Mr. Gus II is the world's largest offshore drill barge. He's as big as five U. S. destroyers. The muscles he uses for lifting himself off the Gulf bottom are hydraulic, with an electrohydraulic servo control for a nervous system.

Mr. Gus's Anatomy

Basic components of Mr. Gus II are:

- A three-deck deep drilling-platform barge, 173 x 104 x 22½ ft in size, which houses personnel and equipment, and serves as the platform for the derrick and drilling bridge.
- A 200 x 180 x 10-ft steel mat with 3-ft scour skirt, ballast and flotation compartments. This plate rests on the Gulf floor during drilling as a foundation.
- Four 10-ft diameter caissons, extending upward 235 ft from the mat through openings in the platform.
- Four 7-ft diameter by 130-ft long piles inside the caissons which are driven 40 to 65 ft into the Gulf floor.

In transit, the mat, partially filled with air for buoyancy, is in contact with the bottom of the platform. Mr. Gus II is towed to approximate position by sea-going tugs. Huge anchors are put out from the four corners of the barge, and the barge is then winched to position by hydraulically powered windlasses.

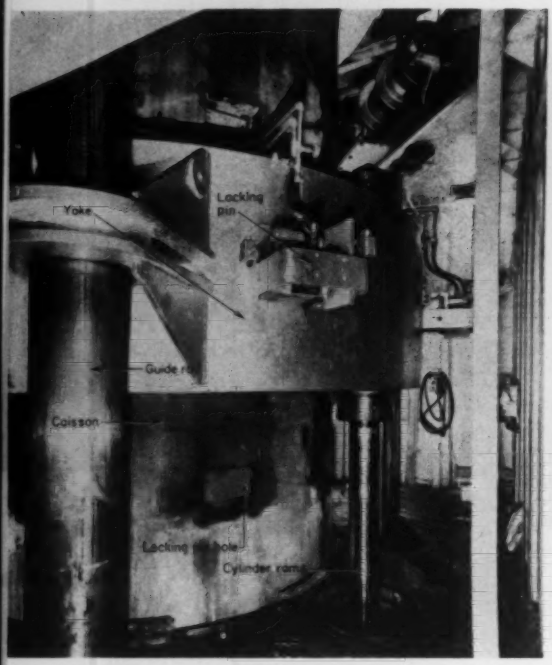
The mat is then lowered by jacking down the caissons until the mat contacts the Gulf floor. Ballast tanks in the mat are filled, piles are driven into the Gulf bottom, and anchors are retrieved.

After piles have been driven, water is drained from ballast tanks in the platform, and the 6000-ton platform is lifted as much as 50 ft above the water (maximum wave height in hurricanes is about 45 ft). Mr. Gus II has operated in record water depths of 136-138 ft.

The well-drilling derrick is then moved hydraulically from its stowed position amidships to the aft end of the platform. Two Oilgear two-way variable - delivery pumps with servomotor lever control supply fluid power to cylinders to move the drilling bridge. These pumps also supply fluid power to a drilling caisson pusher on the bridge which sinks a conductor pipe to the Gulf bottom.

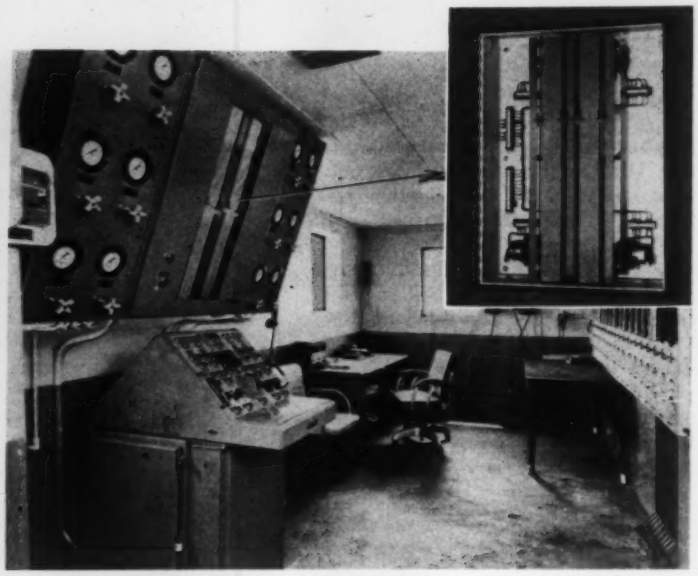
Mr. Gus's Muscles

The four caissons supporting the drilling platform, along with the mat foundation, are raised or lowered by a series of jacking actions. Six 20-in. diameter double-acting



Caissons are lowered

. . . by a jacking action using six hydraulic cylinders. Reinforced holes in the caisson are engaged by locking pins on a yoke to which the cylinders are bolted. A second set of locking pins in the barge platform holds the caissons as the yoke is returned for another stroke

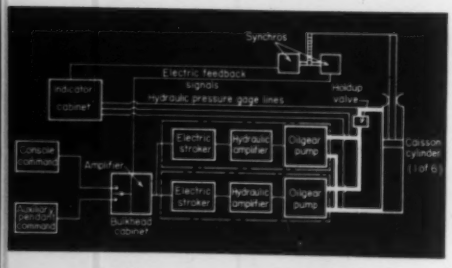


Operational nerve center

. . . handles hydraulic operations from a central room. Servo-controlled indicators in the panel above the control console show caisson position. Controls on the main panel can be used to raise or lower the caissons in synchronism or individually, operate the caisson locking pins, and operate the anchor winches

cylinders are arranged in a circle around each caisson. Ram ends of the cylinders are bolted to a yoke surrounding the caisson and guided on two 20-in. diameter rods.

Total stroke of the cylinders is 8 ft 2 in. Jacking operation starts by extending the rams to full stroke. Eight locking pins in the yoke are moved in radially by air cylinders to engage corresponding reinforced holes in the caissons.



Jacking pumps are controlled

. . . by an electrohydraulic system. Central console command or individual pendants at each station control two Oilgear pumps through an amplifier. Position of the ram controls two synchros which provide a feedback signal to the amplifier and an indicating signal to the ram position indicators on the central panel

Fluid power from two Oilgear two-way variable-delivery pumps operating in parallel (the same ones used for winching the anchor) is directed to the ram ends of the six cylinders to pull down the caissons. Eight locking pins in the platform are then engaged to hold the platform, and yoke locking pins are disengaged in preparation for another stroke.

The four hydraulic systems at the caissons operate independently of each other, but are synchronized through the electrohydraulic control system. Both radial, rolling-piston pumps at each station can be used, or either one independently. Pressure gages for the pumps are located in the central control room. As a safety measure, electric-operated hold-up valves close to each cylinder hold up the mass in case of power or piping failure.

Mr. Gus's Nerve System

All eight pumps for lowering the caissons may be controlled in unison from the central control room on the main platform. A spring-centered hand control determines stroke, and a yoke-position indicator above the console displays position of each of the four jacking yokes within $\pm 1/8$ in.

Caissons can also be raised or lowered individually, and pump delivery adjusted to compensate for load variations, at the central console. Hand pendant controls can be used at individual pumping stations, either for jacking the caissons or operating the anchor winches.

This semiautomatic jacking system centers around the servo controls provided in the Oilgear pumps. Command signal is relayed to a 1/50-hp servomotor geared to a hydraulic force amplifier which controls position of the slideblock in the pump. The slideblock controls direction and volume of oil flow. Feedback signals generated by potentiometers or synchros provide synchronous control of position, velocity, and/or acceleration. An automatic synchronizing system compensates for errors in jacking speed of individual caissons, and shuts down the operation if platform tilt exceeds 2 seconds of arc.

After the mat is "bottomed" and the platform raised above water level, the 7-ft diameter piles are pushed into the Gulf bottom. Two 2-way variable-delivery pumps with servomotor lever controls are located inside each caisson, about half-way down. A jacking system similar to the system used for the caissons is used to drive the piles.

Essential components of GM's electromagnetic steering system include an analog computer, left, mounted in the glove compartment, and two pickup coils on the front bumper, right, which straddle the magnetic path produced by a wire in the pavement. Voltage variations between coils feed into the computer; signals from the computer activate a modified power steering unit. System can work under ice and snow.

Automatic Car Steering Passes First Road Test

Sensing elements, controlled by glove compartment unit, track wire in road. Portends more highway automaticity, says GM

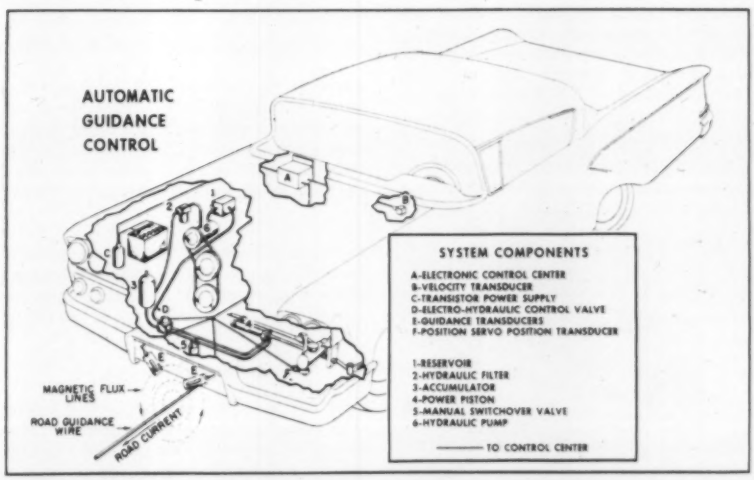
WARREN, MICH.—First successful demonstration of an automatic electronic guidance control passenger car was conducted recently by General Motors. The test car rolled along a two-lane road and negotiated banked turn-around loops at either end with no assist from the driver. To turn off the road or pass another vehicle, the driver merely touched a switch on the steering wheel which cut in the manual system.

Although the new system is still in the research stage, and is limited to steering control, it is considered by GM to be the first "building block" in what may become a more sophisticated system for controlling vehicle spacing, detecting location of cars, and alerting the driver for throttle and brake control.

The electromagnetic control was chosen for its "ultimate simplicity," according to GM researchers. It requires only low-frequency power, its sensitivity is good, and with the cable planted in the highway concrete, it would suffer no weather or radiation interference.

"This isn't an impractical dream," said Dr. L. R. Hafstad, GM research chief. "It reflects an extension of a steady trend toward greater reliance on automatic devices for both vehicle operations and traffic control, as represented by . . . automatic transmissions, and electronic traffic signal systems."

Simplicity of the system enables it to be installed now on public highways where traffic controlled automatically and manually would be mixed for a protracted period. Inception of Federal road program makes consideration timely.



Power for GM's electronic steering system comes from the car engine and electrical system. With power steering and automatic transmission, this extends utilization of available horsepower in today's car engines.

The Panelbuilder

60 YEARS OF SERVICE
CUTLER-HAMMER
MOTOR CONTROL
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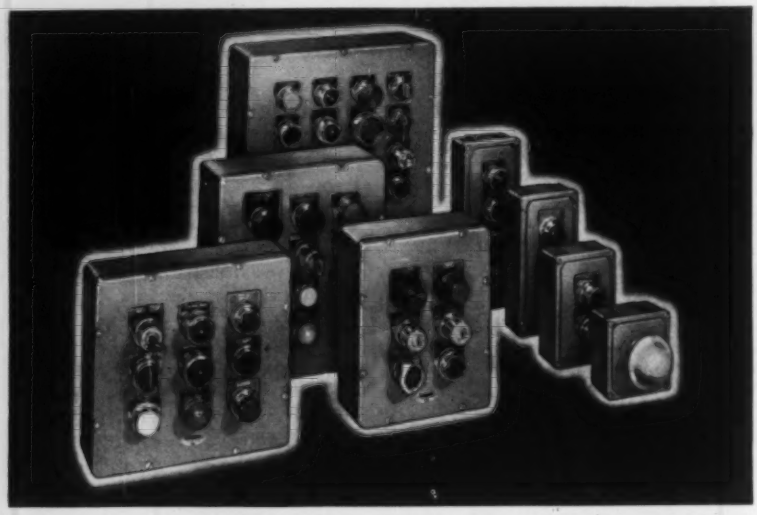
News for and about Panelbuilders



NEW OIL-TIGHT CONTROL STATIONS PERMIT BASE OR COVER MOUNTING OF CONTROL UNITS

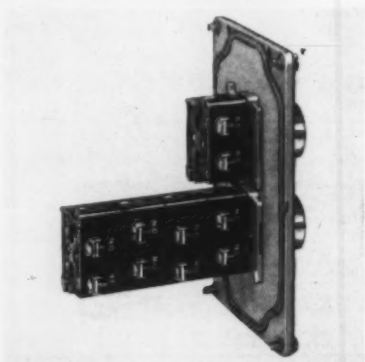
To meet the growing demand for greater flexibility in the assembly of oil-tight control stations, Cutler-Hammer developed a new line of precision die-cast enclosures. These new Cutler-Hammer Control Stations are unique in the fact that they will accommodate either cover or base mounted control units with equal facility. Many have shown a preference for these new control stations because a base mounted push-button, indicating light, etc. eliminates the necessity for hinged wiring.

One to Sixteen Unit Control Stations

Matching Cutler-Hammer Oil-Tight Control Stations are available in eight sizes, the largest will hold sixteen control units. The hinged covers on the six, nine, twelve, and sixteen unit enclosures are snap removable for added working-room during assembly and alterations. The one to four unit enclosures are available in either the normal depth or exclusive shallow depth for use where space limitations are critical. The shallow depth enclosure is only 2 3/16" deep and will accommodate one double contact block for each control unit. All normal depth enclosures, including sizes six and nine, permit a maximum of four circuits per control unit; while the twelve and sixteen unit enclosure provides six circuits per control unit.

Oil-Tight Cavity Mounting Cover Plates

Cutler-Hammer also has available a complete line of oil-tight cover plates for cavity mounted control stations. Machine designers and panelbuilders have shown a marked preference for Cutler-Hammer Oil-Tight Control



Units for cavity mounting because one double circuit contact block takes 40% less space behind the panel than the next smaller unit. Also additional contact blocks are easily tandem mounted providing as many as eight separate circuits in any combination of normally open or normally closed contacts.

C-H Master Design

For further information about these versatile oil-tight control stations and heavy-duty pushbuttons and control units, write today on your company letterhead for the illustrated booklet, EL-178, C-H Master Design. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin.

NEW TRANSISTORIZED RELAY COMBINES FINE-SENSITIVITY WITH HEAVY-DUTY CONSTRUCTION

Many panelbuilders have found this new Cutler-Hammer Transistorized Relay to be particularly useful whenever their control problems call for an A-c relay which will respond to either an A-c or D-c signal between .002 and .02 amperes. The heart of this compact relay is the plug-in type signal amplifying module which contains all the electronic parts. This tough module is practically indestructible, and the plug-in design insures rapid maintenance . . . cuts downtime to a minimum. The Bulletin 13535 transistorized relay requires no warm up time and it is exceptionally quick in operation. Relay is rated at 10 amperes, 110 volts and the price is unusually low. Cutler-Hammer also offers conductive liquid level probes, and photo-cell units for use with the transistorized relay. For further information, write today for Bulletin 13535.

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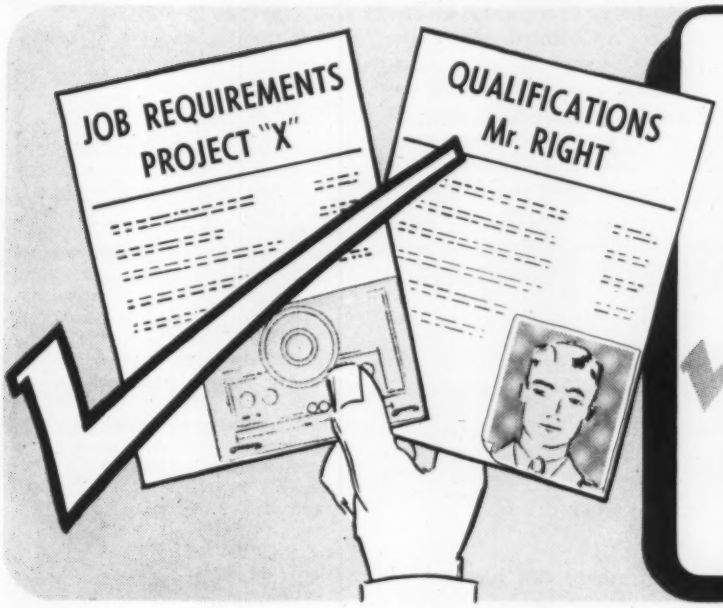

Engineering Placement—

Mr. Right on the Job

PLACING MR. RIGHT in his own element is critical to maximizing engineering productivity. Placement is closely related to work evaluation, serving as the end stage of getting the right man on the right engineering job. As such, according to the survey report, *Engineering Manpower: How to Improve Its Productivity*,* on which these articles are based, placement is critical to the proper utilization of each engineer's ability.

Where placement works

One company contacted described a procedure typical of the placement programs of many large firms. This company has grown to the size where data-processing equipment must be used to keep track of engineering placement information.

The company keeps a digest of information about engineers' abilities on cards. The cards are kept current by the engineer himself and by management progress reports. When a position opens up, the cards are first searched to locate men with proper qualifications. After a check is made of additional and more complete records, the men are interviewed. On this basis, one is selected to fill the job.

A vivid example of what good placement procedure combined with careful job evaluation can do, was brought out in a survey made by the National Society of Professional Engineers. They cited a large eastern utility company which turned a shortage of engineers into a surplus. A careful study was made of all its engineer employees to determine if they were performing 100 per cent engineering work and to obtain in detail a picture of their assignments and potentialities. The results showed that more than 850 engineers spent an equivalent of only 45 per cent of their collective time on engineering work. The company followed up by analyzing each job.

They then rearranged engineers for better utilization and supplemented them with supporting personnel. Five years after institution of the program, the company employed 150 less engineers of all categories. The remarkable aspect of the program is that through careful replacement of personnel lost through normal attrition, the engineering staff was producing more engineering work, and engineers, individually, had greater opportunity for advancement. As a result, engineers as well as the company benefited.

Mr. C. F. Hood, President of United States Steel, has voiced the view:

- It is both wasteful and unfair to place a competent engineer in a position which has been found less than suitable for him as regards its functions, responsibilities, and authority. Job classification may be a cold and austere term for this technique, but it has proved an invaluable tool for the efficient use of manpower.

Where placement hurts

Evaluations of the engineer before his first job assignment and continually thereafter were the formal features of most placement pro-

*©1957, G. A. von Peterffy.

grams studied in the survey. For several reasons the periodic appraisal is the phase of placement that most companies, to a certain degree, were found to neglect.

Engineers are most often evaluated by means of personal observations and periodic appraisals, but too often the system becomes lax. Supervisors are generally unimpressed that, to be effective, evaluation must stem from a conscious and systematic procedure. Oftentimes, supervisors do not systematically and formally review their subordinates' work or discuss such reviews with the engineers. In fact, supervisors are often relieved of all responsibility for subordinates' appraisal and the job is handed to the personnel department. This is one good way to bypass the person best suited to evaluate the engineer on the job, and to damage the supervisor-engineer relationship as well.

Replies to the survey showed not only that periodic appraisals are often neglected, but also that some companies' engineers remain assigned to projects from which they might be profitably transferred. After a project has progressed to a certain stage, technicians or specialists could be brought in, and experienced engineers could be transferred to other jobs. However, this is frequently not done and, as a result, engineering productivity is lost.

Placing an engineer in a job is clearly related to evaluating the job itself. As pointed out in the article on planning, most companies do a poor job of evaluating their engineers' work. Invariably, poor work evaluation must have adverse effects on engineering placement practices. But once this is recognized and placement is judged on its own merits, it is found that placement practices in industry are paid far more attention than work-evaluation procedures.

How engineers are judged

It was clearly indicated by the survey that most of the companies contacted place an engineer on the basis of ability. For experienced engineers, ability is judged primarily on past experience and current work record. Recent graduates are most often placed on the basis of field of study and grades attained. Some distance behind ability as the placement criteria were the engineer's interests, followed by company needs and tests, in that order.

In reply to the survey question, "On what basis are engineers in your company assigned to their jobs," companies gave a variety of answers.

- Starting jobs are assigned on the basis of field of engineering studied. As engineers gain experience, they are judged by this, If they have previously been through a training program and are hired for a specific position, experience is a major factor.
- Experience! I want to work with experts.
- Evaluation of the capability of the man is based on background and experience and the requirements of the job.
- For junior engineers, we consider: 1. Need of our research activity. 2. Individual interest. 3. Education. 4. Job experience. For professional engineers, we consider: 1. Need of our research activity. 2. Education. 3. Experience. 4. Interest.
- For the initial assignment, we are interested in education and satisfactory personal qualifications. Later, job performance and demonstrated ability to see jobs through, whether big or little, weigh heavily on the reassignment and progress within our organization.
- Interests, education, experience, and ability.
- Our engineers are assigned to task teams on a highly fluid basis, depending on the problem or assignment and how their individual knowledge, abilities, and skill can contribute to success. Development and product engineers are assigned on a basis of product experience.

Aptitude tests

Many companies, primarily large ones, employ psychological tests to evaluate engineers, before and after hiring. The tests are met with mixed emotions on the part of the engineers. Many resent such tests because they conflict with their professional status. However, very few of the companies base their entire evaluation on them. They use tests primarily as a guide. Many companies do not use them at all. It appears from results of the survey, however, that aptitude and psychological testing of engineers in industry is on the upswing.

Next article in this series will appear in the April 3 issue. It will deal with the importance of leadership, management-engineer communications, and the supervisor's responsibilities.

Which Job for Mr. Right?

1. Almost all of industry's engineers are placed in jobs that utilize their training and experience to some extent. However, most companies do a better job in the initial placement phase than in the subsequent performance evaluation phase of the placement and reassignment process.

2. More effective placement can do much to increase engineering productivity.

3. Ability, based on education for recent graduates and experience for older engineers, is by far the criterion most often used to place an engineer. Engineers' interests are frequently secondary considerations.

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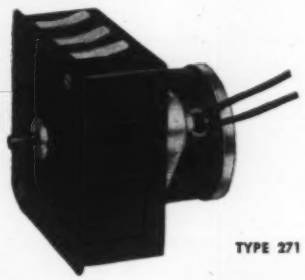
Over the years, Cramer engineering and manufacturing skill has built an unequalled reputation for quality in timers and timing motors. Today, the same skill . . . plus cost-cutting innovations in production methods . . . brings you four new units with the same outstanding quality at substantial price savings. Ask for prices, get the detailed specifications, and you'll see that Cramer quality means economy *now* — not just in the long run.

Cramer Controls Corporation
Box 6, Centerbrook, Connecticut

New Interval timer



TYPE 271

Cramer Type 271 is a compact, manually-set timer for "on" and "off" control of a wide variety of equipment . . . such as driers, ovens, photographic apparatus, battery charges, and various types of production machinery. Turning the dial pointer clockwise to the desired setting transfers the load switch, starts the motor and initiates timing. The pointer then indicates timing progress as it moves back toward zero. At the end of the set time, the load switch transfers to its first condition, and the motor stops.

TIME RANGES: 11 standard ranges, from 45 seconds to 24 hours.

LOAD SWITCHES: 1 or 2, as required; SPDT open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

TIMING ACCURACY: within ½ of 1% of full scale time.

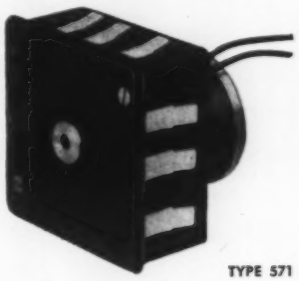
CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-271

New Cycling timer



TYPE 571

Cramer Type 571 provides reliable and inexpensive repetitive switching, or programming, in a wide variety of built-in applications . . . such as vending machines, displays, domestic appliances, production or process equipment, and many others. The timer starts when power is applied, stops if power is interrupted, and resumes cycling at the same point when power is restored. It can be wired for single cycle and stop operation, or for continuous cycling. During each cycle, 1 to 4 load switches are actuated, at times and for durations determined by cams cut to the user's specifications.

SPEEDS: 18 standard speeds, from 1 rpm to ⅛ rpd.

LOAD SWITCHES: 1 to 4 as required; SPST or SPDT, open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

CAMS: precision-cut to user's programming requirements, locked to a square shaft that eliminates slippage.

TIMING ACCURACY: within 1½% of full cycle at each operating point.

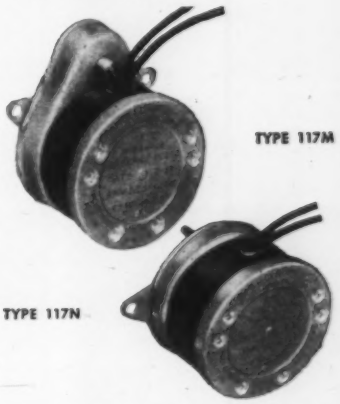
CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-571

2 new timing motors



TYPE 117M

TYPE 117N

Cramer Type 117M and Type 117N are unequalled examples of performance-plus-economy in permanent-magnet synchronous timing motors. Delivering a full 30 in. oz. torque at 1 rpm, these powerful, accurate, reliable motors incorporate all of the engineering advances that have made Cramer the first choice of designers who put quality first. And their low cost is fast making them the first choice of large volume manufacturers who must put economy first. With standard gear train (Type 117M) or space-saving round gear train (Type 117N), a great range of standard speeds, and enough torque to handle the heaviest loads without extra linkages, they are ideal for appliances, vending machines, animated displays, timers, recorders, instrument drives, and many other applications.

SPEEDS: Type 117M—60 rpm to ½ rpd; Type 117N—60 rpm to 1/12 rpm. Special speeds available on order.

TORQUE: 30 in. oz. at 1 rpm.

GEAR TRAIN: fully enclosed, precision hobbed throughout.

OUTPUT SHAFT: stainless steel, selected to order from many standard or special forms available.

ROTOR: permanent magnet, with bronze oilite bearings and permanent lubrication; low rotor speed permits wide range of output speeds.

ROTATION: right, left, or dual (oscillating); patented "No-Back" mechanism; synchronous speed reached within 2 powerline cycles.

FRICTION: 1-way in rotation direction, or 2-way.

TEMPERATURE RISE: 35°C.

AMBIENT TEMPERATURE: −4°F to +131°F.

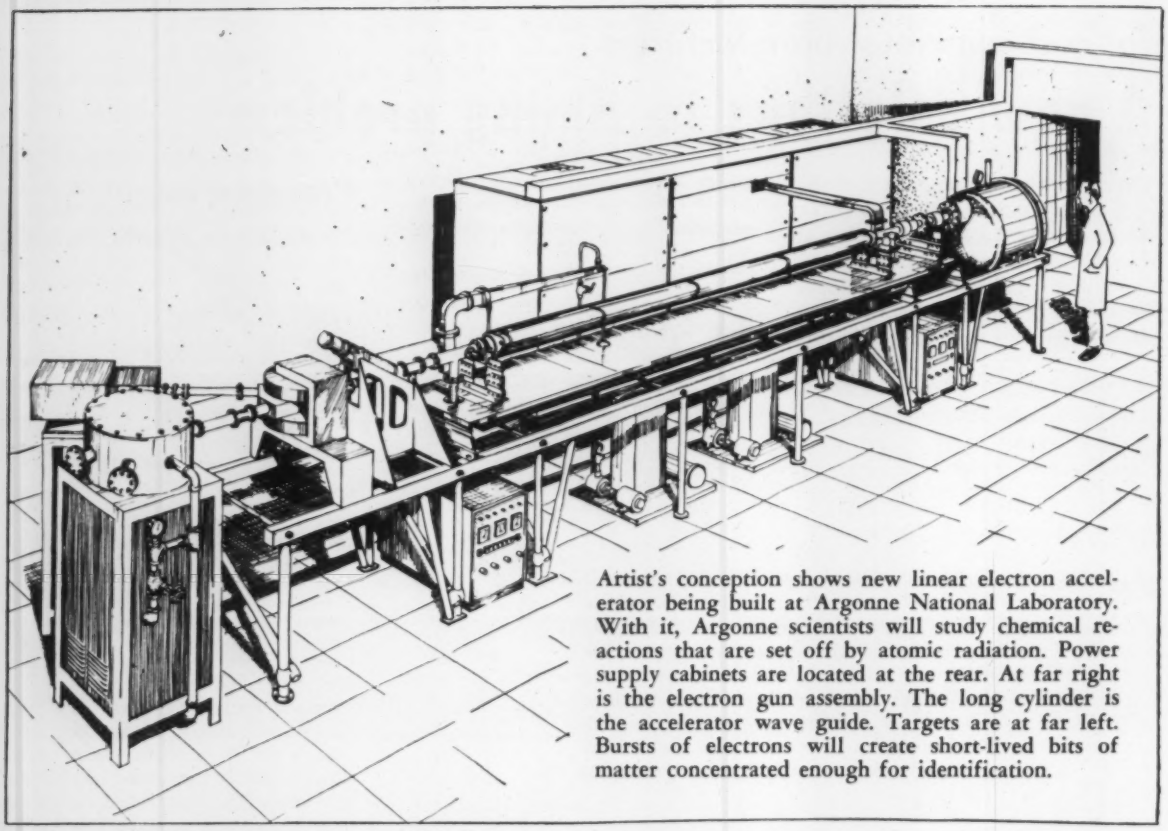
RATINGS: 115v and 220v, 60 and 50 cycles.

WRITE FOR BULLETIN PB-117

WHEN TIME IS YOUR PROBLEM, CALL CRAMER

CRAMER CONTROLS
CORPORATION

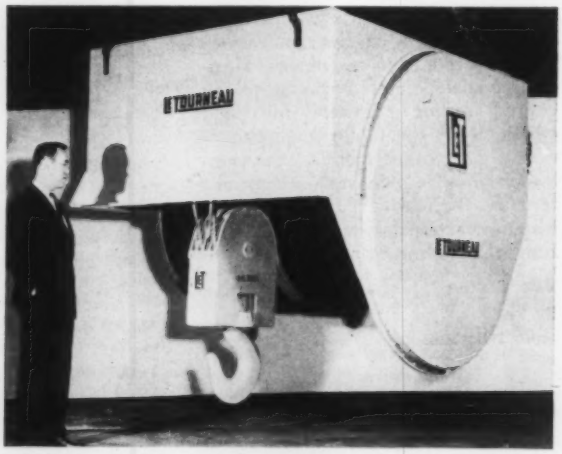
Circle 416 on Page 19



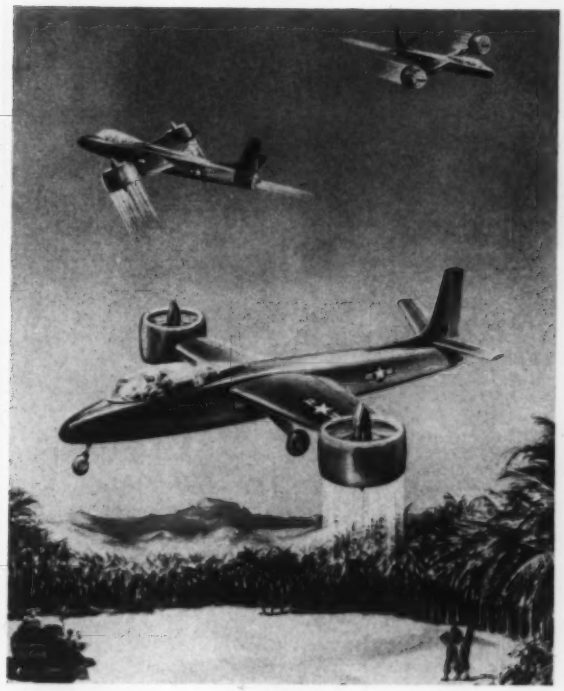
Artist's conception shows new linear electron accelerator being built at Argonne National Laboratory. With it, Argonne scientists will study chemical reactions that are set off by atomic radiation. Power supply cabinets are located at the rear. At far right is the electron gun assembly. The long cylinder is the accelerator wave guide. Targets are at far left. Bursts of electrons will create short-lived bits of matter concentrated enough for identification.

TO PROTECT LIVING ORGANISMS from radiation effects, scientists will seek an answer to, "what happens during a chemical reaction that is catalyzed or set off by atomic radiation?" With the help of a new research tool, a high-energy electron accelerator, Argonne scientists hope to detect directly the short-lived intermediate products of such reactions. Knowledge of these primary products and their basic reaction mechanisms may enable them to use radiation better to preserve foods and to produce new chemical products. Applied Radiation Corp. is building the 15-ft long accelerator, powered by a 5-megawatt klystron.

MOST POWERFUL DOZER ever in production, this 600-hp, 104,000-lb working weight model has just completed extensive field testing on the Illinois Tollway Project. Built by the Construction Machinery Div. of Clark Equipment Co., the 52-ton dozer is nearly 27 ft long, has a top speed of 28 mph. A 12-cylinder diesel engine powers it on four 33.5 x 33—26-ply tires



HEFTY HOIST is to a regular hoist as a bus is to a car. This giant, built at R. G. LeTourneau Inc., has a capacity of 45 tons and lift height of 103 ft. Its huge drum carries 922 ft of cable, measures 4 ft in diam and 6½ ft in length. It can raise and lower a full-capacity load with a precision of 0.008 in., controlled by a quick-action electric motor and a special system of twin-brake control. One brake is regenerative electric, in which the hoist motor also works as a generator. The other half of braking is electromechanical.



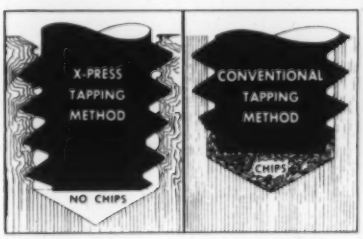
ANY APPROACH to any airfield is possible with the Doak 16, Army's newest VTOL aircraft currently under test. Doak (for Doak Aircraft Corp.) has ducted wingtip propellers that rotate 90 deg; convert in flight from vertical takeoff to normal horizontal flight. Where airfields are available, the plane uses them, since horizontal takeoff requires less power—enables the aircraft to lift more weight in the form of additional fuel. Powerplant is a single Lycoming T-53 shaft turbine engine. Originally financed privately, Doak is being considered for use as an airline feeder.

ONE-STAGE ROCKETS, fission powered, may be the best answer for space travel, according to Rocketdyne Div., North American Aviation. In concept, engines, below, would use the virtually limitless energy of fission to convert the working fluid into ultrahigh-temperature gases. Since gases would be free of the relatively heavy products of normal combustion, they would surge through rocket nozzles at tremendous speeds, creating propulsive thrust many times greater than that of current chemical rockets. Rocketdyne is doing nuclear-powered rocket research for the Air Force.

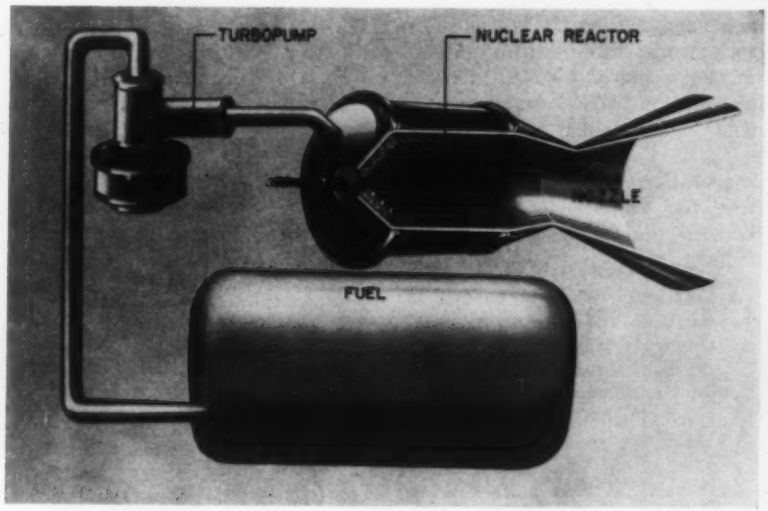
Strong Threads in Ductile Metals Pressure Formed by No-Cut Tap

PHILADELPHIA — Stronger threads and less tap breakage are features of a new tapping process developed by Besly-Welles Corp.

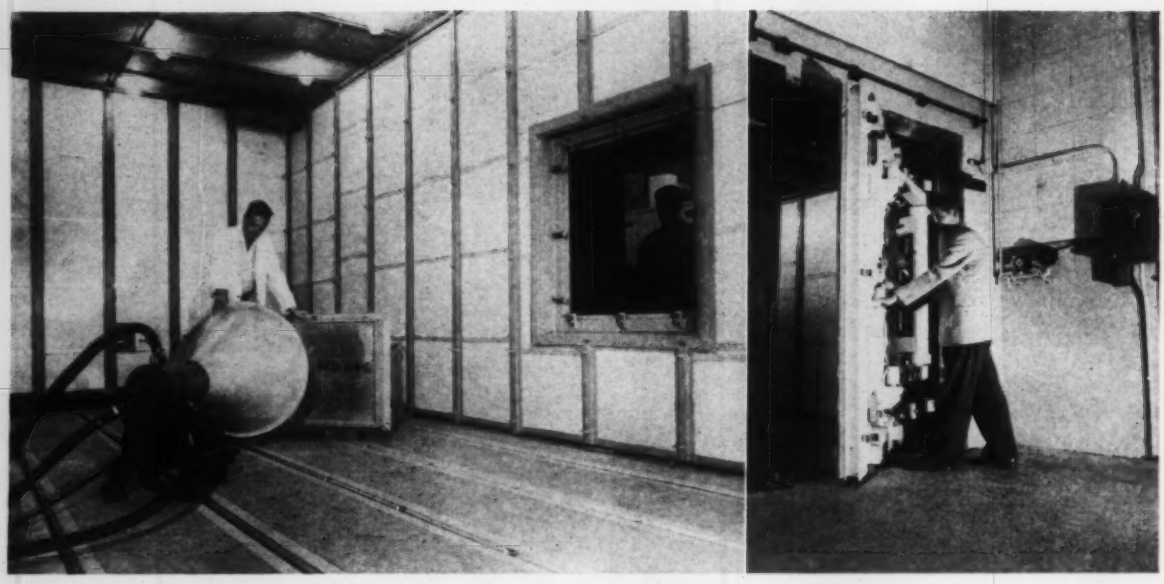
Instead of cutting, the new process, using a special Besly tap, or swaging tool, forms threads under pressure by reforming longitudinal fibers in the workpiece. This results in a much stronger thread.



Since the tap has no flutes or cutting edges, no chips are produced and tap breakage due to jamming and clogging is eliminated.



The new process is said to work favorably with various ductile metals, including copper, brass, aluminum, lead, zinc, and leaded steels.



BANK-VAULT DOORS are used on two sonic test cells to contain the tremendous volume of destructive sound generated. New sound laboratory at Boeing Airplane Co. is used to determine the effects of engine noise on airplane structure. During a test, the specimen is placed directly in front of the exponential horn. Sonic generating equipment will provide 190 db of pure sine-wave sound for test purposes. Thorough soundproofing reduces noise level outside a cell to only 70 db. All controls and instruments are outside the test cell where sound level, resonant frequency, time, vibration, and stresses are measured.

U. S. Engineering Enrollment Reaches All-Time Peak

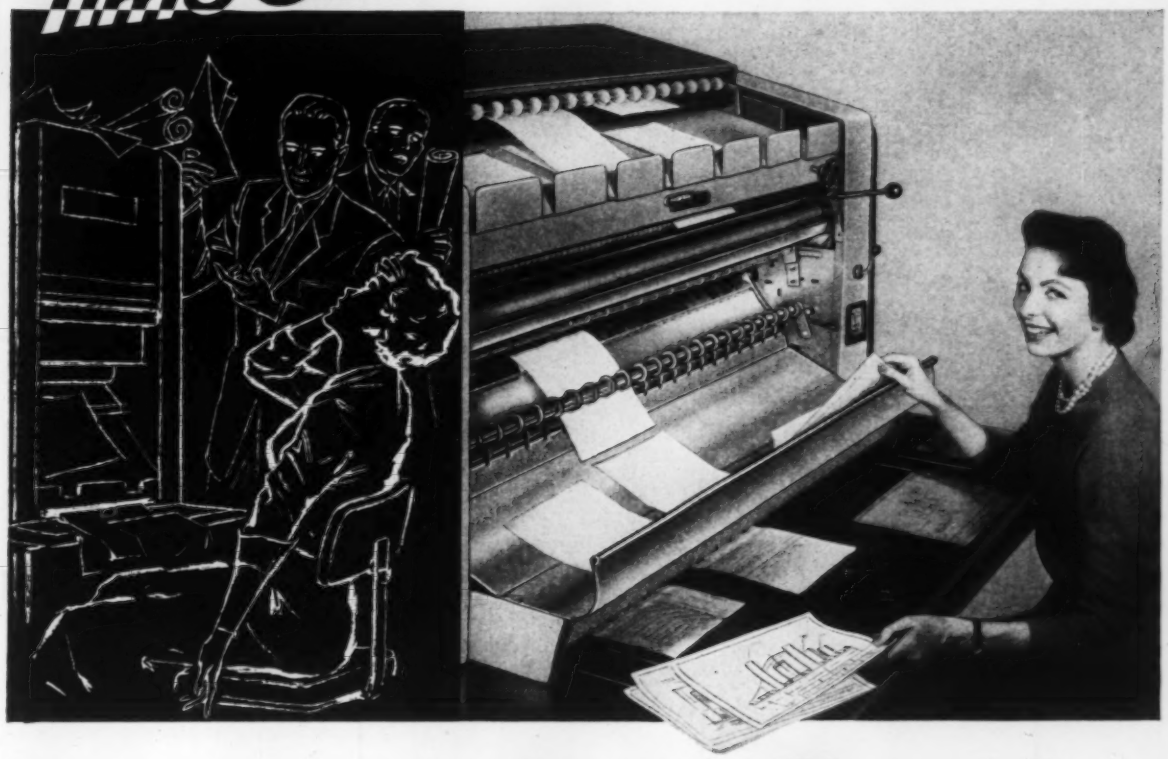
Part-Time, Evening Classes Show Substantial Gains

WASHINGTON — Principal findings of a survey of engineering enrollments and degrees in colleges show engineering enrollment at an all-time high and an over-all increase in part-time and evening enrollments. The annual survey, made by the U. S. Office of Education in co-operation with the American Society for Engineering Education, included the following among its findings:

1. Total engineering enrollment in the U. S. and its outlying parts reached an all-time high of 257,777 students in the fall of 1957. This represented a 5.5 per cent rise over the previous peak, reported in 1947.
2. Engineering enrollment has increased each year since 1951.
3. Part-time and evening undergraduate engineering enrollment in the fall of 1957 included 30,458 students. This is 17.1 per cent greater than the year before.
4. Enrollment for the doctor's degree in the fall of 1957 increased to 4180 students, a 22.9 per cent rise over the year before.
5. Evening student enrollment for the doctor's degree increased to 690 students; up 30.7 per cent over the year before.

AMBIDEXTROUS PLOW, equipped with both right and left-hand bottoms, can plow back and forth along the same side of a field, always turning the furrow the same way. Built by International Harvester, the new farm tool is especially suited for plowing irrigated land, hillside terrain, or terraced areas where it eliminates necessity of back furrows or dead furrows. Hydraulic controls on the tractor raise and lower the plow and activate the roll-over mechanism that provides the unique two-way feature.

Time Out?



. . . or Out in Time!

Why tolerate "time outs" and aggravations of older reproduction equipment? Modern Copyflex gives you "out in time" efficiency, pays for itself in short order!

Compare the performance of your equipment with these modern reproduction advantages. See if you can really afford *not* to get Copyflex?

More Operator Conveniences. Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Extra-large delivery trays, automatic separation, automatic stacking, and front-or-rear delivery further speed operator's work.

Faster Mechanical Speeds. New models offer sharply increased speeds—up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.

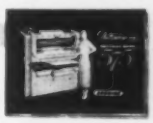
Sharp, Uniform Prints. Developing solution is applied *directly* to exposed print assuring complete, positive development at all speeds and on all types of materials.

Problem-Free Installation and Operation. Clean, quiet, odorless . . . Copyflex requires no vents or plumbing, needs only an electrical connection for operation.

If you're not getting these important advantages of Copyflex, then every day you delay is costing you time and money. You owe it to yourself and your company to investigate modern Copyflex by mailing the coupon below.

BRUNING *Copyflex*

Send for Your Free Copy!



Charles Bruning Company, Inc., Dept. 33-K
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Offices in Principal U.S. Cities
In Canada: 105 Church Street, Toronto 1, Ont.

Please send me the booklet on your new model 575 and information on the Copyflex process and machines.

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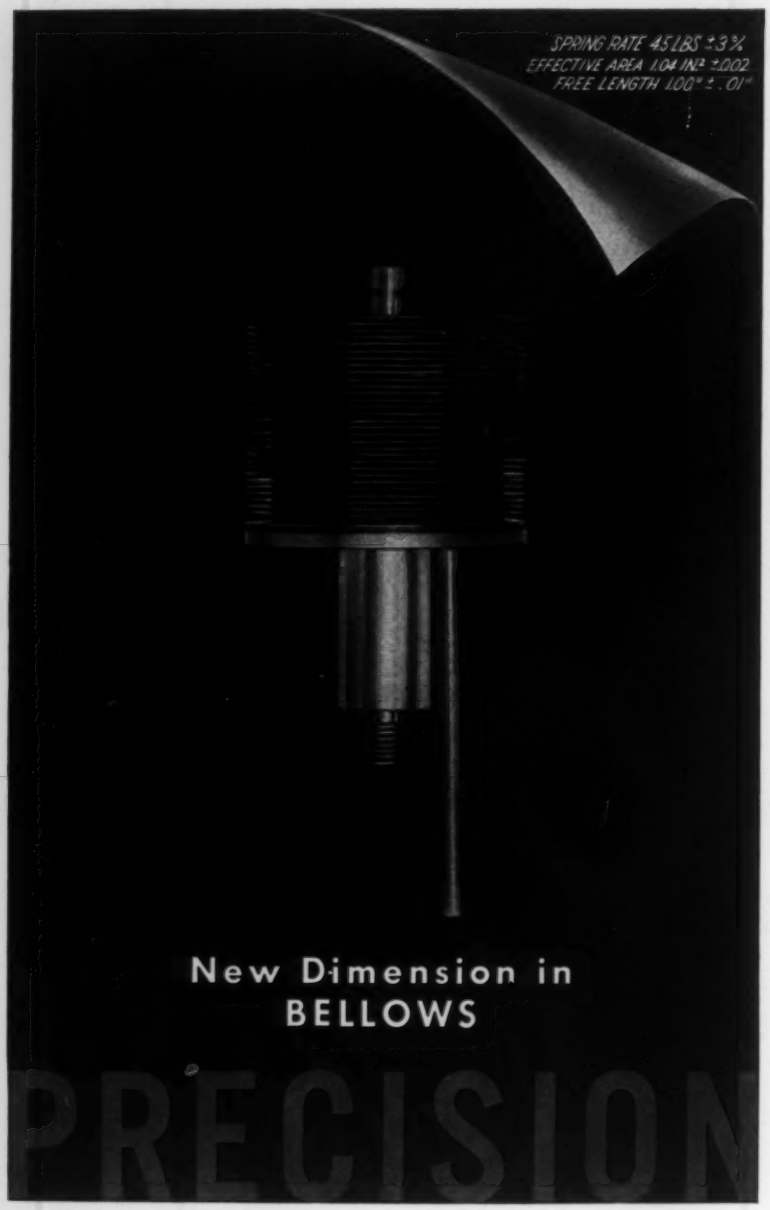

When your specifications for design and manufacture of precision bellows require unusual know-how or close scheduling, Belfab Corporation may be your best source. Precision welded bellows by Belfab have helped solve many "impossible" problems—and almost literally helped develop new dimensions in bellows precision.

Preliminary designs, catalog and data sheets furnished on request without obligation.

THE BELFAB CORPORATION

AGAWAM, MASSACHUSETTS • DAYTONA BEACH, FLORIDA

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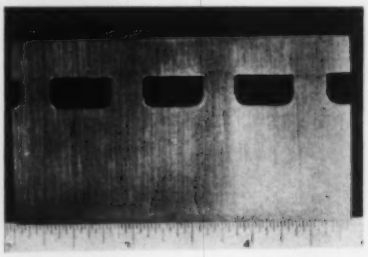
6. The award of 27,748 first-level engineering degrees during the 1956-57 academic year marked an increase of 17.8 per cent over the year before.

During the 1956-57 academic year, the highest percentage of engineering degrees was awarded in the field of electrical engineering.



BUILT-IN COILS provide heat transfer through heavy composite plate; eliminate double-wall construction and bulky surface coils. Base plate, usually steel, is channeled before nonferrous cladding is added. Coil-like passageways thus carry heating or cooling medium at selected distance from either surface. Developed by Chicago Bridge & Iron, the new process is said to work with a wide range of cladding and base plate materials.

Computer System Automatically Abstracts Technical Articles

Repeated Words and Phrases Are Basis for Classification

NEW YORK—First reports on an electronic technique for preparing abstracts of technical and scientific articles have been announced by International Business Machines Corp. The articles are analyzed, sentence by sentence, by an IBM 704 Electronic Data Processing System. The machine then selects the most significant sentences and reproduces them on an electronic printer. At a glance an engineer or scientist can determine whether or not the article is of value to him. The technique is the outgrowth of research on information retrieval by H. P. Luhn of IBM's Yorktown Heights Research Cen-

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ter.

In this abstracting technique, called Auto Abstracting, the article to be treated is first punched out on IBM cards, then transcribed to magnetic tape, in which form it is ready to be fed to the machine. Optical scanning systems, now being developed, may eventually eliminate the card stage entirely. Documents will be inserted directly into the machine where they will be "read" in a fraction of a second and written in the same time on tape.

As the tape is read, the program, or set of instructions stored in the computer, is activated. The computer determines the significance of words by measuring the frequency with which they are used individually and the frequency of combinations and couplings.

The entire article is scanned and submitted to a statistical analysis of word usage and placement, from which a table of values is made. The machine then analyzes each sentence based on this table and awards a significance factor to it.

Depending on the degree of these factors, it will select the several highest ranking sentences and print them out. If the significance is very high, a single sentence might serve as the entire abstract.

The advantage of machine abstracting is that only the original statements of authors appear in the abstract and are not subject to misinterpretations by human evaluators. Also, the selection of the key sentence or sentences is made through mathematical analysis, thus providing a constant standard.

There are a number of tedious information-seeking problems to which electronic data processing methods may be applied:

1. The patent office has the task of first classifying millions of variations in machine designs offered as new patents, then finding the entire class of similar ones already filed and determining the degree of variation.

2. Doctors are looking into the possibility of diagnosing diseases by feeding the symptoms to a computer that has memorized the thousands of combinations of symptoms for every known disease.

DIAMOND NEWS ABOUT ROLLER CHAIN DRIVES, APPLICATIONS AND NEW PRODUCTS.

Stock Diamond Roller Chains and Sprockets provide outstanding design freedom

The big Fairmont W 55 makes short work of weed burning and snow melting, performs with efficiency and has the practical rugged construction that guarantees minimum upkeep.

Of special interest to designers is the drive system on the Fairmont W 55 Weed Burner. There are six forward and six reverse speeds plus a two stage torque converter. The propelling engine runs at efficient RPM regardless of track speeds of up to 25 MPH.

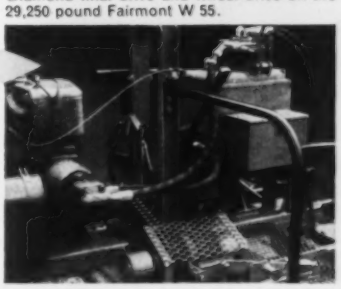
A three strand Diamond Roller Chain serves as final drive. Single strand Diamond Roller Chains are used to drive the rail wheels through sprockets mounted on them.

Fairmont designers realized many advantages through the use of these Diamond drives. First, they placed driving shafts where most advantageous since center distances make no difference to roller chain drives. Secondly, the Diamond Chain drives are left open for easy lubrication and inspection. In this service rugged Diamond Chain delivers all the engine power, allows for springing action of the undercarriage and provides long service-free performance.

Diamond final drive and wheel drive on the 29,250 pound Fairmont W 55.

On the W 90 Fairmont Tie Handler, Diamond Roller Chain drives the cable drum to both extract and insert ties in the roadbed. Driven by a hydraulic motor and through a speed reducer, this Diamond Chain supplies a steady high cable pull. Another Diamond Chain is used to propel the W 90 in either direction.

All chain used by Fairmont is standard stock Diamond Roller Chain. It is readily available in any quantity both to Fairmont and their customers —at stock item prices.



Heavy duty double pitch Diamond Roller Chain drives the cable drum. Single strand Diamond propels the W 90 Tie Handler.

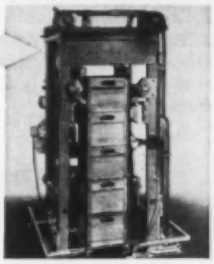
GRAVITY DOES THE WORK

(with the help of Diamond Roller Chains)

Stacking from the top down is simplicity itself with the Lathrop-Paulson case stacker. The accummulated stack is ready for discharge the instant it is completed—either by in-floor or on-floor conveyor.

Diamond Roller Chain supports the carriage on which the cases are stacked. Flexible, dependable Diamond Roller Chain assures continuous, smooth, automatic operation.

More and more machine designers are becoming aware of the many advantages of *stock* Diamond products. **Write for new Catalog 757 giving you the latest data on the many stock Diamond Chains and Sprockets available to simplify drives, conveyors and other power transfer problems.**



L-P Case Stacker makes use of Diamond power drives from the speed reducer and to support the carriage. Here again, *stock* Diamond Roller Chain has been used to advantage on highly specialized equipment.

DIAMOND CHAIN COMPANY, Inc.

A Subsidiary of American Steel Foundries

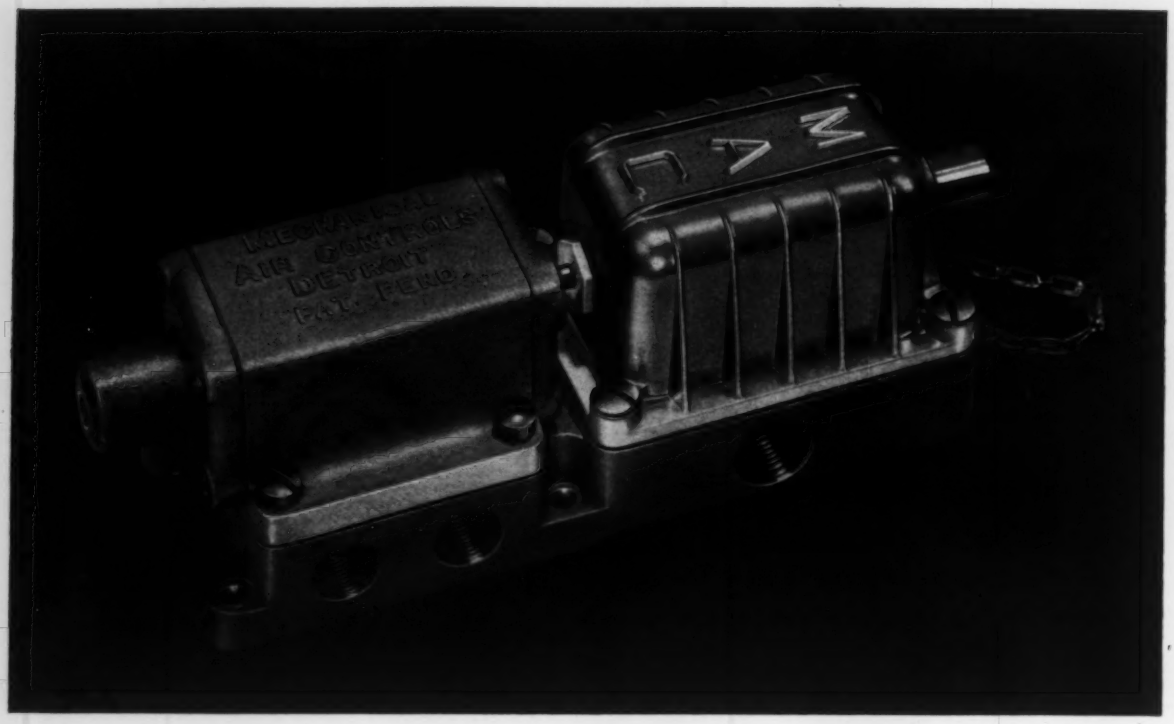
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Ind.

Offices and Distributors in All Principal Cities

Write for new Catalog 757

DIAMOND ROLLER CHAINS

Circle 419 on Page 19



When is an air valve truly J.I.C.?

Only when it meets *all* J.I.C. requirements. To our knowledge this new MAC series *alone* can pass the test completely.

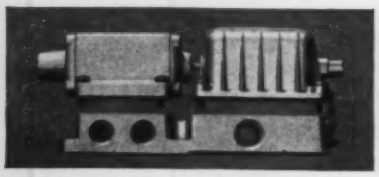
Example #1. It is the only valve with completely independent body and solenoid. Either can be removed separately from the base without disturbing the other. This eliminates confusion of responsibility between electrical repair and mechanical repair . . . greatly simplifies maintenance and repair.

Example #2. Cover assembly contains a manual overide operator which includes a "lock-in" position for safety. Cover is dust-proof, splash-proof, chained to base. Solenoid is inoperative when cover is removed.

Example #3. The base contains an integral conduit box with threaded conduit connections. Ample space . . . easier wiring . . . more compact valve.

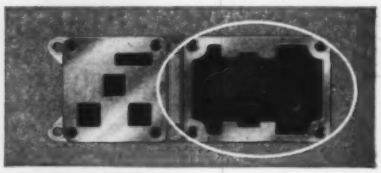
Extra features in this J.I.C. series include the MACsolenoid. It is positively shock-resistant mounted . . . has no metal-to-metal contact with stationary parts . . . by actual test operates nonstop and *without any failures* millions of cycles longer than other solenoids.

Compare this new MAC series with any other "J.I.C." valve. They alone meet *or surpass* every J.I.C. specification. They are typical of the engineering excellence you find in all MAC valves. For information call a MAC representative listed at the right, or write direct.



1 Independent body, solenoid, base

2 Safe, manual overide operator



3 Integral conduit box in base

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park, Detroit 37, Michigan

MAC

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MICHIGAN
BAY CITY—Fred Kober, 506 So. Chilson St., TWinbrook 2-2629
FLINT 2—Kober Sales Engineering Co., 1115 Root St., CEdar 2-7165
WESTERN MICHIGAN—Everett Adams, 17212 Sharon Road, Chesaning, Michigan, VIctor 5-3446

MINNESOTA
MINNEAPOLIS 8—Air & Hydraulic Equipment Co., 15 E. 38th St., TAylor 3-6118

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MISSOURI
ST. LOUIS COUNTY—Oscar E. Jost Co., P.O. Box 6, St. Ann, HArrison 8-4488

NEW JERSEY
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(**SOUTHERN**) Automation Aides, 1618 Willow Ave., Philadelphia 26, LaMott, Pennsylvania, MElrose 5-5555

NEW YORK
BUFFALO 25—C. H. Tepas Co., 137 Lamarck Drive, CIrcle 3210
NEW YORK 17—Machinery & Machine Supplies Co., Inc., 305 East 47th Street, PLaza 8-0744

OHIO
CINCINNATI 2—Fluid Power Engineering Co., 205 Keith Bldg., MAin 1-6640
CLEVELAND 9 (PARMA)—Fluid Power Engineering Co., 5451 Broadview Rd., FLorida 1-1199

OREGON
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PENNSYLVANIA
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PITTSBURGH—Machinery & Machine Supplies Co., Inc., 1307 Rutherford St., LEhigh 1-1235

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MEMPHIS 5—Branch-Merwin Tool Specialists, 477 N. Bellevue, BRoadway 8-6102

TEXAS
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WASHINGTON
SEATTLE—The Rucker Co., 1000 4th Ave., South, MAin 2783

WISCONSIN
MILWAUKEE 17—Neff Engineering Co., 5856 No. Pt. Washington Rd., Edgewood 2-1579

CANADA
MONTREAL—L. S. Tarshis & Sons, Ltd., 450 McGill St., Quebec, PLateau 2963
TORONTO—Trevor Babbs, National Time & Signal Co., 72 Shilton Rd., Agincourt, Ontario, OXford 1-4857

MECHANICAL AIR CONTROLS, INC.
DETROIT 37, MICHIGAN
MAC

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3. Given the specifications and cost limitations, chemical compounds and resins may be selected by computers from the thousands that have been developed, especially in the area of synthetics and plastics.

New Insulation Helps Missile Builders

Performs More Effectively The Higher it Flies

NEW YORK—A new insulation developed by Johns-Manville Research Laboratory is claimed to have thermal conductivity one-half that of other known insulating materials. Developed especially for use in aircraft and missiles, the new insulation, called Min-K, will perform two vital functions:

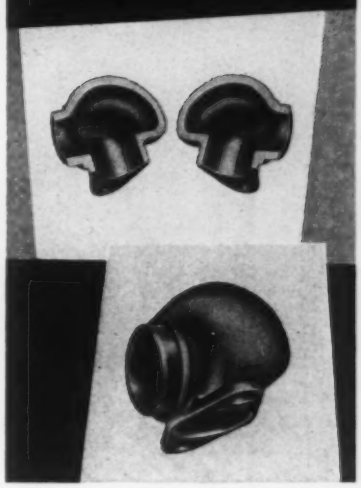
- Provide more effective protection to temperature-sensitive instruments and controls,
- Increase the range of rockets and missiles by at least 20 per cent through increasing their fuel capacity, since the new material requires about one-third as much space as conventional insulating materials to do the same job.

A unique feature of Min-K, according to J-M scientists, is the fact that its conductivity decreases appreciably at lowered atmospheric pressure, and consequently at higher altitudes. For example, at an altitude of 10 miles thermal conductivity is decreased by as much as 50 per cent. In addition, the new insulation can withstand temperatures to 1300 F for extended periods of time; is said to have excellent strength and resistance to vibration, and can be shaped to comparatively close tolerances.

Min-K was described as a bonded structure reinforced with fibrous media, and containing appreciable quantities of particulate matter, the ultimate structural elements being extremely small.

This creates pores in the structure so minute that a large portion of the gas molecules collide with the walls of the structure rather than with other molecules. Thus,

two halves *don't* make a hole!



. . . *with* **INVESTMENT CASTING** *it's made in one piece.*

We don't tackle casting problems halfway at Hitchiner.

Here's a cross section where the inside dimensions are greater than the holes. Originally made in sections and assembled — now the whole unit is precision cast and is lighter and stronger.

Where application requirements demand that a part be of intricate shape; of unusual contour, of fine detail, or of metals difficult or impossible to machine — investment casting provides an efficient and economical solution.

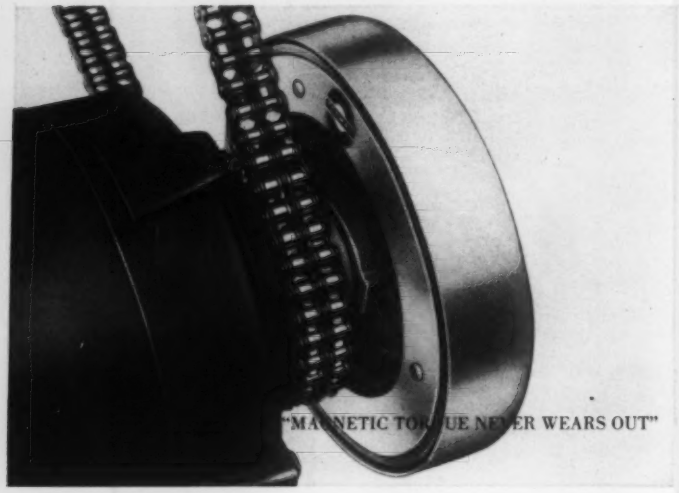
Only your production costs are cut in half when you utilize the efficiency of investment casting. You save time and plenty of labor. And . . . you'll have a wide selection of metals; the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

If you use metal in your product, investigate the possibilities of investment casting. Write us today for our free brochure.

HITCHINER
MANUFACTURING COMPANY, INC.
MILFORD 13, NEW HAMPSHIRE
Representatives in Principal Cities

Circle 421 on Page 19

UNIQUE IN THE FIELD!

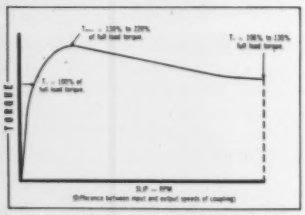


COMPLETE MOTOR DRIVE PROTECTION *with*

Whitney-TORMAG DRIVE

FULL OVERLOAD PROTECTION • CUSHIONED STARTS • HIGH EFFICIENCY • SELF-CONTAINED • TORQUE RATED • SLASHES POWER COSTS • ELIMINATES MAINTENANCE • FOR DIRECT OR POWER TAKE-OFF DRIVE •

Proven throughout industry, the new Whitney-Tormag Drive is a frictionless, permanent magnet-type power transfer unit, which insures against motor burn-outs and costly down time. Now available in 1 H.P. and 2 H.P. (at 1750 RPM input) sizes, ready for quick installation. Additional sizes up to 15 H.P. will follow. Torque ranges—2 ft. lbs. to 45 ft. lbs.



EXCLUSIVE OVERLOAD PROTECTION!

Operating curve illustrates fixed characteristics for optimum performance.

See These Cost Cutting Features

- Runs at full stall (100% slip) without harm to motor or driven element.
- No power loss in fluids, particles or seal friction . . . no pumps, coolers or exciters to cause power drain.
- Meets new N.E.M.A. frame specifications — compact, ready to install in minutes.
- Slip start design allows use of lower H.P. motors—cuts motor, starter and power costs.
- Cushioned starts eliminate shock, reduce maintenance costs.
- Operates from minus 60° F. to 150° F.

Available from stock through your Whitney Chain Distributor.

A Product of Whitney CHAIN COMPANY

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ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVE

the amount of heat transferred by molecular conduction is reduced substantially below that which would occur in "still air." Certain other materials in the structure minimize transmission of radiant energy through the insulation.

Min-K will undoubtedly find many commercial applications, according to Johns-Manville officials, although its present cost is prohibitive.

Polaris Development Described by Navy

Design of a Sea Missile Posed New Problems

WASHINGTON—Special problems in adapting a ballistic missile for submarine armament were discussed recently by the Navy's representative at a recent meeting of the Air Force Association.

In describing the Navy's Polaris missile development, Rear Admiral W. F. Raborn, Navy's director of special projects, declared that "The basic problems have all passed from the scientific to the engineering stage . . . no new break-throughs are required to carry the weapon into reality."

Fuel, the first and basic problem, has been resolved with recent breakthroughs in solid fuels and solid fuel motors. This, for the first time, made sub-launched ballistic missiles feasible—since a submarine, naturally, cannot carry large quantities of unstable and corrosive fuels.

Size and weight, relatively unimportant in land-launched missiles, were also a basic problem. To pay its way as a weapons system, the nuclear sub had to carry more than one missile. Raborn declared that Polaris designers have again exceeded expectations: "A single sub can carry a surprising number of Polaris missiles."

Launching platform—the submarine—posed an extremely difficult problem. There is always some slight roll or pitch to the ship even when submerged and stopped. Exact positioning at the time of firing is currently being provided by new navigational instruments and procedures. In ad-

dition, the problem of training personnel in fire control procedure is being done on a new "ship's motion simulator." This device, new to the Navy, is much like aircraft simulators used in pilot training.

Meetings

AND EXPOSITIONS

April 2-4—

American Society of Mechanical Engineers. Instruments and Regulators Conference to be held at the University of Delaware, Newark, Del. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 8-11—

Society of Automotive Engineers. Aeronautic Meeting, Aeronautic Production Forum and Aircraft Engineering Display to be held at the Hotel Commodore, New York. More information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

April 14-17—

Design Engineering Show to be held at the International Amphitheatre, Chicago. Design Engineering Conference, sponsored by the Machine Design Div. of ASME, will be held in conjunction with the show. Additional information is available from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

April 14-18—

American Welding Society. National Spring Meeting to be held in St. Louis. The show will be held at Kiel Auditorium April 15-17; technical sessions will be presented at Hotel Statler Hilton April 14-18. Further information can be obtained from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

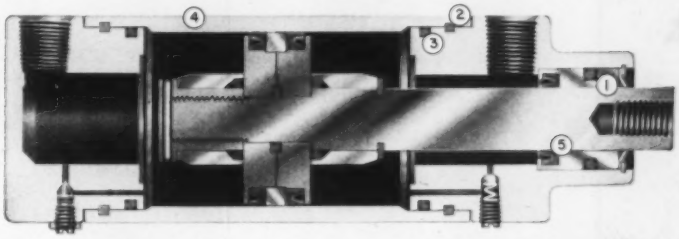
April 17-18—

Institute of Environmental Engi-

CARTER

CYLINDERS

AIR OR HYDRAULIC



Designers get 3 Important Benefits by Standardizing on the Superior CARTER Design

THE CARTER DESIGN

1—Full 1 to 1 Meehanite cartridge rod bearing.

2—Key type stainless steel locking ring. Allows 360° rotation of ports.

3—Leakproof "O" Ring seal between head and wall.

4—Precision honed heavy wall tubing—6 to 1 safety factor.

5—Spring loaded "V" packing on rod end gland.

IMMEDIATE DELIVERY FROM STOCK

SAVINGS IN SPACE—40% savings in space. Helps build more compact, functional equipment. Where other cylinders won't fit, Carter will!

IMPROVES PRODUCT QUALITY Carter cylinders are stronger, more efficient. Completely leakproof! Better performance, longer life. The finest cylinder for your product.

ENGINEERING SERVICE and sales in 40 locations throughout the United States, Canada, Mexico, and Europe.

FREE DESIGNERS' FILE

Details on air, hydraulic, valves, built-in-valve types. All necessary data for designers.

CARTER CONTROLS INCORPORATED

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AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

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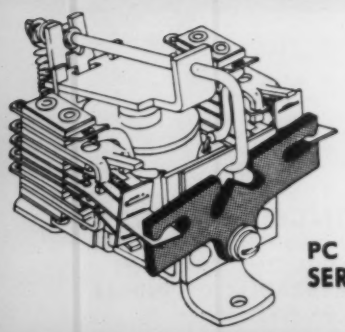
NOW! TWO-COIL PERFORMANCE AT SINGLE COIL COST!



PC SERIES

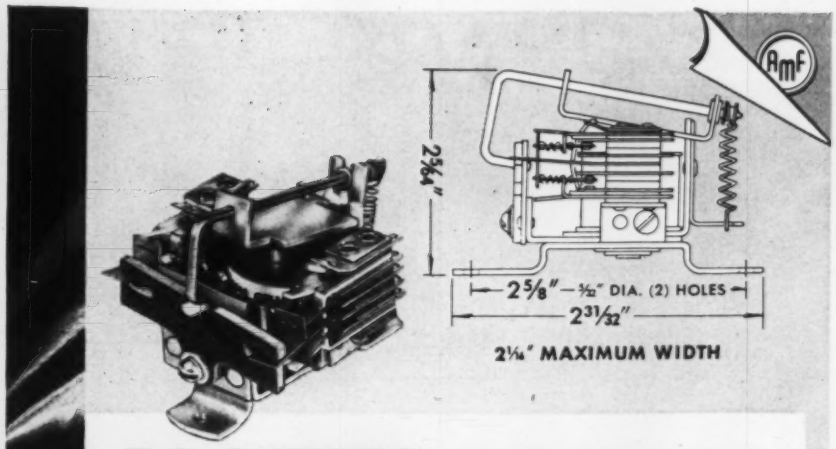
This new series, the PC, is an ingenious impulse latching relay which employs a single coil and armature to activate an insulated rocker arm. Switching is positive, fast (30 milliseconds).

Its low cost, dependability and versatility make it ideal for a wide range of uses. For example, two leading TV set manufacturers use the PC in their remote control circuits as an "off-on" switch. It is also used by a maker of automatic garage doors. Conveying systems, automatic processing equipment, flow controls—the PC is right for these applications and many more.

Contact arrangements are available up to 4 Form C (4PDT), and the snap-action contacts are rated 5 amps. at 115 V. AC resistive. The relay may be ordered open, as shown, or in a metal dust cover.

Write or wire today for complete information.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA / SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



PC SERIES ENGINEERING DATA

GENERAL: Description: Single coil, impulse latching relay.
Insulating Material: Laminated Phenolic.
Insulation Resistance: 1500 megs. min.
Breakdown Voltage: 500 V. RMS.
Ambient Temperature: —55° C. to +85° C.
Weight: 5 ozs. (open)
Pull-In: DC, 75% / AC, 78% } for nominal voltage.
Operate: 30 MS.
Terminals: Pierced Solder Lugs
Coil: Two #20 AWG Wires
Contacts: One #20 AWG Wire
Enclosures: "A" Can.

CONTACTS: Arrangements: 4 Form C. max. (4PDT)
Material: 1/8" dia. Silver Cadmium oxide gold flashed.
Load: 5 amp. @ 115 V. AC resistive.
Pressure: 20 grms. min.

COIL: Resistance: .016 to 34,500 max.
Power: DC, 9 watts. / AC, 18.4 Volt Amps. } at nominal voltage.
Duty: Intermittant.
Insulation: Cellulose acetate wrap; varnish impregnated (open).

MOUNTINGS: Two 13/32" dia. holes on 2 5/8" center.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Mail the coupon below for further engineering data on P&B's new PC Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new PC Series relays, plus the new compact catalog of P&B standard relays.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

See our catalog in Sweet's Product Design File

neers. Second Annual Meeting to be held at the New Yorker Hotel, New York. Additional information is available from IEE headquarters, 9 Spring St., Princeton, N. J.

April 20-24—

Scientific Apparatus Makers Association. 40th Annual Meeting to be held at the El Mirador Hotel, Palm Springs, Calif. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

"This is our small but efficient drafting department."

April 21-23—

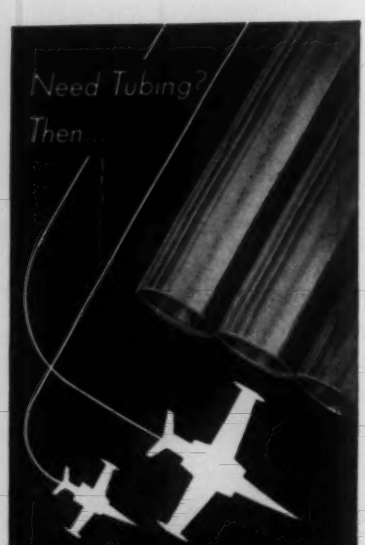
Metal Powder Association. Fourteenth Annual Meeting and Show, to be held at the Sheraton Hotel, Philadelphia. Further information can be obtained from association headquarters, 130 W. 42nd St., New York 36, N. Y.

April 21-23—

Association of Iron and Steel Engineers. Spring Conference to be held at the Dinkler-Tutwiler Hotel, Birmingham, Ala. Additional information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

April 22-24—

Electronic Components Conference to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from Mr. David M. Knox, Packard-Bell Electronics Corp., 12333 W.



Look No Further For Quality...

Because BISHOP small diameter tubing is not excelled in accuracy of I.D. and O.D. . . . in dimensional precision . . . in tolerances . . . in finish.

Whether it be for a precision part in an instrument . . . a heat exchanger in today's high speed aircraft . . . a thermocouple . . . an electronic or atomic application.

Wherever tubing is needed to meet corrosion, heat, shock, stress, psi pressure resistance and vibration . . . for highest quality and performance specify BISHOP tubing, at comparable prices.

SEAMLESS AND WELDED AND DRAWN STAINLESS STEEL TUBING

Mechanical, Capillary, Hypodermic and Aircraft Grade

(.008" to 1.000" O.D.— .003" to .083" Wall)

NICKEL AND ALLOY TUBING

(up to .625" O.D.)

TUBULAR FABRICATED PARTS

Flanged, Flared, Milled, Slotted, Swaged and Threaded

GLASS-TO-METAL SEALING ALLOYS

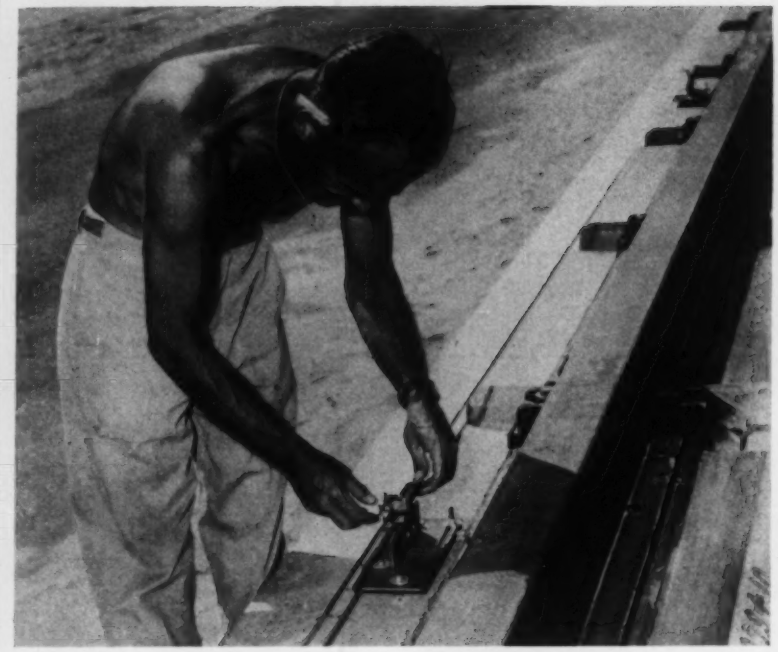
CLAD METALS & COMPOSITE WIRES

Catalogs on Request. For Prompt Service, Fast Deliveries Call Malvern, Pa. 3100

JB

J. BISHOP & CO. Platinum Works

Stainless Steel Products Division, Malvern, Pa.



NATION'S LONGEST AND FASTEST ROCKET-SLED TRACK, extending over a 7-mile course at Holloman Air Force Base, will be completed early this year with the aligning of its final section. The rails, designed for testing rockets, aircraft, and missile components at speeds up to Mach 4, will be aligned to within ± 0.005 in. by Delta Design Engineers Inc. Technician is shown installing Invar tape jig on interrupter blade during precision installation. The special tape, after calibration, has been corrected by tension to exactly 130,000 ft.

Olympic Blvd., Los Angeles 64, Calif.

April 22-24—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Hotel Cleveland, Cleveland. Additional information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 24-25—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Hotel Statler Hilton, New York. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 1-8—

American Society of Tool Engineers. Tool Show to be held at Convention Center, Philadelphia. Additional information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

May 6-9—

Western Joint Computer Conference to be held at the Ambassador Hotel, Los Angeles. Sponsors are American Institute of Electrical Engineers, Association for Computing Machinery, Institute of Radio Engineers, National Joint Computer Committee. Further information is available from Mr. R. E. Utman, Electrodata Div., Burroughs Corp., 460 Sierra Madre Villa, Pasadena, Calif.

May 12-15—

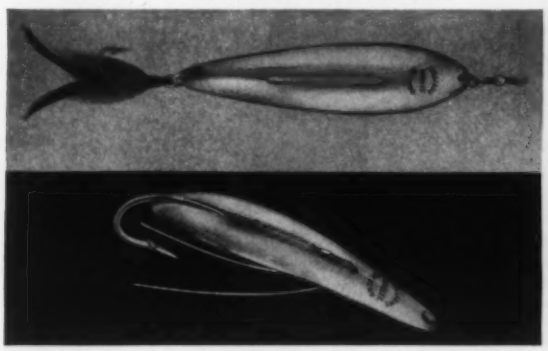
American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Bellevue-Stratford Hotel, Philadelphia. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

NEW BRASS CUTS POLISHING COST

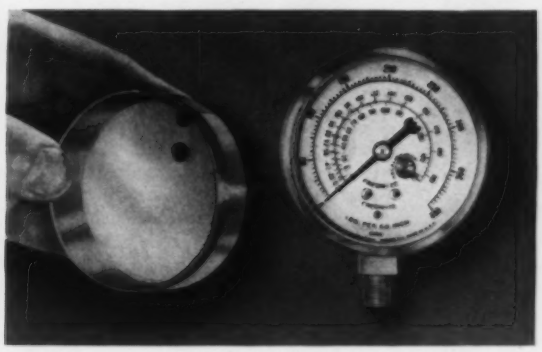
also gives you clean, easy drawing and forming, plus higher physical properties—Formbrite,® Superfine-Grain Drawing Brass by Anaconda

AIRGUIDE Instrument Co., Chicago, gets high luster finish on bezels for its famous weather instruments at 50% lower cost since it switched from ordinary drawing brass to Formbrite. Airguide does the presswork—says Formbrite "draws and forms excellently." Driscoll & Co. (above) polishes the bezels.

BAROMETER in Chippendale style, "Mayfair," is one of the broad line of brass-trimmed instruments made for home and marine use by Airguide.



FISHING LURES made by Williams Gold Refining Co., Inc.—"Wabler," top and "Weedler," below—are polished for plating by tumbling. Switching from ordinary yellow brass to Formbrite cut costs more than 40%.



MARSH Instrument Co., Skokie, Ill., dropped a finishing operation and gets a "mirror finish" with a light buff, by using Formbrite. Marsh reports that finishing cost was cut 40% and that forming is "excellent."

Wherever finishing is an important cost factor in formed or drawn products, Formbrite in sheet and strip is designed to save you money. In brass wire alloys for cold-heading and upsetting, it gives a stronger, springier, more abrasion-resistant product. For more detailed information, write for Publication B-39. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

5843

FORMBRITE

SUPERFINE-GRAIN DRAWING BRASS

a product of

ANACONDA®

Made by The American Brass Company

Circle 426 on Page 19

Compare competing products.

It's an important part of your job to visit the 1958

DESIGN EN

INTERNATIONAL AMPHITHEATRE CHICAGO

APRIL 14-17, 1958

Try things out for yourself.

Discover new materials.

Pick up hundreds of new ideas.

Talk to the man who engineered it.

New ideas are priceless. One new part, component or material can eliminate a bottleneck in your thinking, give you a completely fresh approach to a problem.

The 1958 DESIGN ENGINEERING SHOW teems with new ideas, new products, new services . . . the very latest developments from the top inventive minds of America. Engineers and technical experts from over 400 leading manufacturers will be on hand to go over your blueprints and job specifications with you, answer your questions, explain their new product applications, help you solve your product design and development problems.

GINEERING SHOW

What you'll see:

- Mechanical components
- Electrical and electronic components
- Metals
- Non-metallic materials
- Finishes and coatings
- Shapes and forms
- Hydraulic and pneumatic components
- Power transmission equipment
- Research and testing equipment
- Engineering equipment and services

Concurrent A.S.M.E. Conference

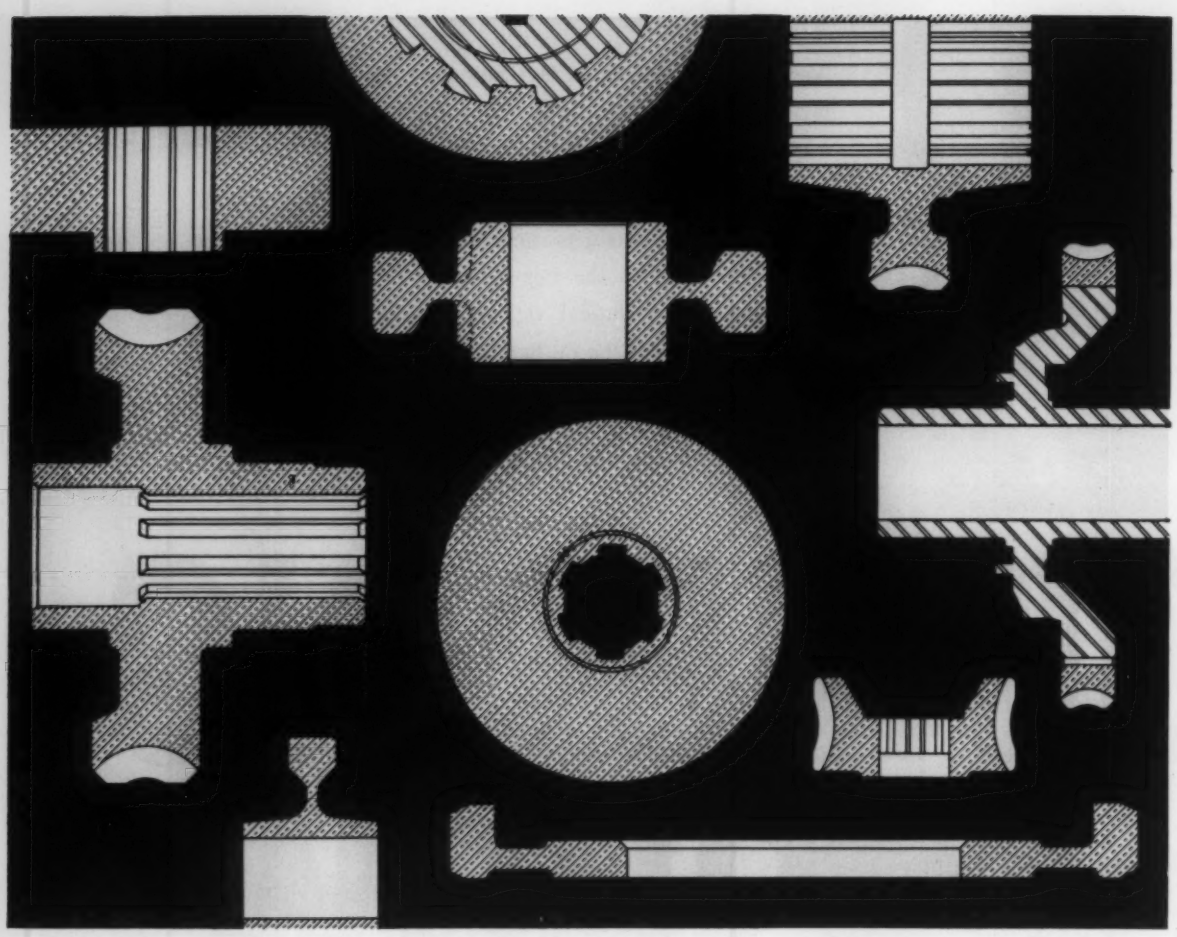
Sponsored by the Machine Design Division, American Society of Mechanical Engineers, the 1958 Design Engineering Conference will be the most important event of the year in your field. Speakers and panel members are top authorities in their subjects. Separate sessions on *mechanical, electrical* and *materials* problems allow engineers to devote their time to areas of primary interest.

Send for these tickets today!

Rapid Registration Tickets speed your entry into the Show. Send for as many as you need. For show tickets and information on Conference Registration, write:

Design Engineering Show
341 Madison Avenue
New York 17, N. Y.

Circle 427 on Page 19



Gear Blanks . . . of any shape or size . . . we cast them in BRONZE!

Big gears are our specialty

Whatever the shape or size of the gear blank you need, NBD can cast it for you in gear bronze, nickel bronze, aluminum bronze, manganese bronze—to your specifications. Want iron or steel hubs cast in? We can do it. Want castings furnished rough, rough machined, or finished machined? Want sand castings, shell moldings, chilled rim or chilled three sides? You name it.

And we cast many blanks centrifugally . . . in sizes up to and even beyond 72″ in diameter. Centrifugally cast gears have proved their added strength, toughness and long-wearing characteristics for many problem applications. Perhaps they can do a job for you.

Got a metallurgical problem? NBD specializes in bronze metallurgy and casting techniques; has developed over 40 special alloys for gear blanks, bushings, bearings, pump components and other parts.

Take advantage of NBD's experience and knowledge of bronze alloys. Three strategically located plants are available to give you fast service. Call or write us for quotes or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

717 Grant Building, Pittsburgh 19, Pennsylvania

PLANTS IN: CHICAGO, ST. LOUIS, MEADVILLE, PA.

Circle 428 on Page 19

The common denominator at IPC . . . is "CUSTOM"

Custom design + Custom tooling + Custom manufacture . . . IPC Oil Seals, in synthetic rubber or leather, are specifically designed to solve a particular sealing application.

Eliminate costly production delays and product failure by specifying IPC oil seals at the design stage. Our engineering staff will carefully check all conditions of your application before recommending an IPC Oil Seal or packings for you. IPC's "custom" oil seals and packings insure longer effective service under the most extreme conditions of pressure, temperature, abrasion and speed.

Contact your IPC representative or call us today.

PACKINGS / OIL SEALS / PRECISION MOLDING

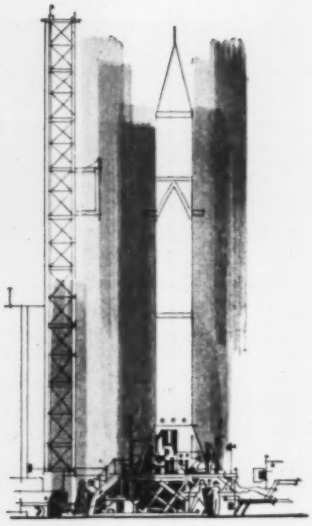
BONDED BY IPC

1. Bonded Washer Seal Double Lip Wiper
3. Bonded Washer Seal Straight Lip
5. Bonded Washer Seal Straight Lip With Garter Spring
7. Bonded Case Seal Straight Lip
9. Bonded Case Seal Straight Lip With Garter Spring
11. Bonded Case Seal Straight Lip Thin Rind Type
13. Rubber Covered Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
4. Bonded Washer Seal Limited Contact Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
10. Bonded Case Seal Limited Contact Lip With Garter Spring
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
14. Rubber Covered Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire P2

Quality... from start to finish!

Versatile ACIPCO Centrifugally Spun Tubes

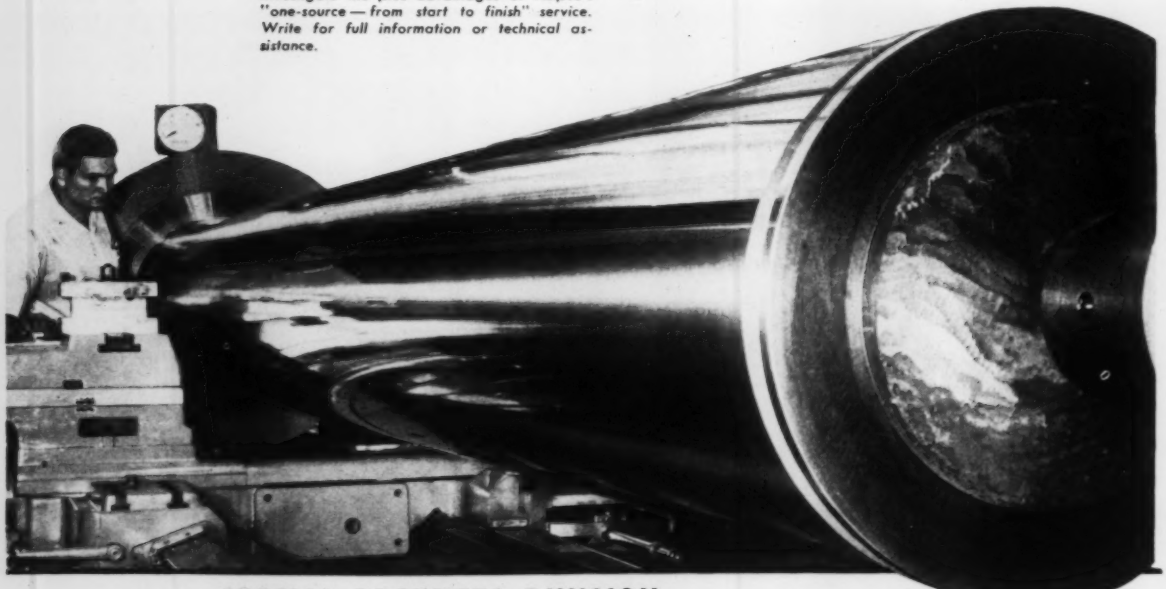


Look at that surface! Belt-polished to ±.0015″ tolerance and 25 microinch finish, this 20′ long, 26.25″ OD, Type 4130 steel tube was produced at ACIPCO for use as a hydraulic cylinder plunger. This application graphically demonstrates the completeness of ACIPCO's extensive Machine Shop facilities.

ACIPCO can turn and finish up to 60″ diameters and 41′ lengths . . . hone up to 29″ ID's and 16′ lengths. Turning, honing and other related machining equipment occupy more than 100,000 square feet of modern Machine Shop construction.

ACIPCO tubes are available to you "Custom Spun" in lengths up to 16′. . . diameters up to 50″. . . and thicknesses up to 4″. Welded assemblies can be supplied in any transportable length. ACIPCO produces standard and special analyses in steel and cast iron, including heat and corrosion resistant stainless steels. Tubes can be furnished as-cast, rough machined or finish machined, including honing.

Investigate the plus advantages of Acipco's "one-source — from start to finish" service. Write for full information or technical assistance.



SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

BIRMINGHAM 2, ALABAMA

AVAILABLE NOW

A full line of General Electric fhp motors to help you lower your costs, increase sales

Circle 431

HERE'S PROOF

Service Proved –

TROUBLE-FREE OPERATION

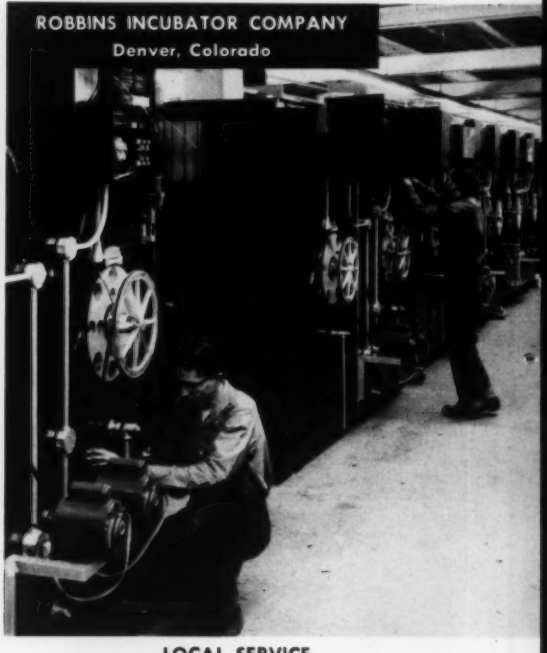
"Our fans are used in a variety of operations and we have had consistent trouble-free performance from G-E fhp motors under all conditions. This means dependable operation in the field, which promotes greater acceptance of our products."

PACKAGED UNIT

"The compactness of G.E.'s motor enables us to give our customers a package unit, rather than use individual parts, at no increase in cost. Fast replacements can be made with Zero-Max Speed Reducers with no worry about alignment problems."

MOTOR VERSATILITY

"The versatility of General Electric fractional horsepower motors allows us to apply many ratings to our 100 Series Speed Reducers. We can now offer a broader selection of drives."



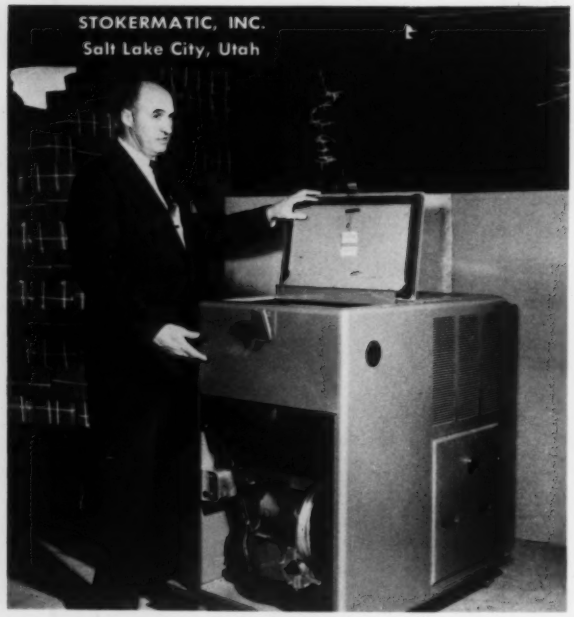
LOCAL SERVICE

"Dependable motor performance and quick, local motor service are musts with our incubator customers. G.E.'s network of Small Motor Service Stations give us the back-up service we need...and expect!"

- - General Electric motors can help

REDUCED WEIGHT 35%

"When we switched to G-E motors, we cut the weight of our medical pumps 11 pounds; 35% less weight for a nurse to carry. Reliable operation under all conditions is essential for life-saving equipment and G-E motors meet this requirement."

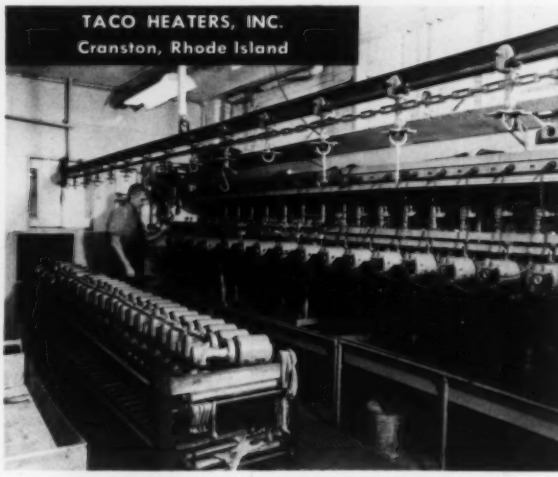


QUIET OPERATION

"Most of our automatic coal-burning space heaters are installed in living rooms where quiet operation is a must, and the silent operation of G-E fhp motors has become a big plus that helps increase our sales. Our customers prefer G.E., too!"

SMALL SIZE

"The compact size of G.E.'s motor helped us to greatly simplify blower applications on our furnaces. G.E.'s fast, efficient engineering service helped us solve many special application problems, too."



CONSTANT QUALITY

"We put all of our hot water circulating pumps through rigid tests before shipping. Better than 99% of all G-E motors we've tested have passed every check . . . ahead of any other motor we've tried!"

p you improve your products, too!

Here's Why General Electric's Complete Line of Fhp Motors Can Produce Results Like These for YOU!

Nearly 10,000,000 General Electric Form G motors have been sold since the design, the first in the new NEMA 48- and 56-frame ratings, was introduced. Hundreds of manufacturers have saved countless thousands of dollars by taking advantage of all the benefits of the General Electric Form-G motor . . . the motor that set ***new*** standards.

You can realize the same benefits by taking advantage of the advanced-design features proved by millions of motors now in use.

COMPLETE LINE of these motors simplifies selection. There's a G-E Form-G motor for practically any fhp motor application you have.

SMALLER SIZE of G-E fhp motors means a smaller, more compact product. The "years ahead" G-E motor is 40% smaller and 50% lighter in weight than old-style motor designs.

MINIMUM MAINTENANCE makes your product easier for customers to use. A 50% greater oil capacity and a highly efficient oil retention system provide double lubrication life, eliminate oiling completely on some applications.

LONGER ELECTRICAL LIFE results from the use of Mylar* polyester film insulation. Mylar has a moisture resistance 35 times as great and a dielectric strength 8 times as great as ordinary paper insulation.

COMPLETE MOUNTING VERSATILITY provides easy solutions to design problems. You can mount a G-E fhp motor in any position, and eliminate the need for costly "specials." Moreover, on both ***solid*** and ***resilient*** base motors, you can rotate the motor within its cradle or remove the cradle entirely to meet your exact requirements.

WANT MORE INFORMATION? Your nearest G-E Apparatus Sales Office will be glad to show you how you can improve ***your*** product with General Electric "years ahead" motors. They also can arrange for quick delivery of the motors you need. Write for Bulletin GEA-6424 to Section 702-70, General Electric Company, Schenectady 5, N. Y.

*Registered Trade-mark of DuPont Company.

Progress Is Our Most Important Product

GENERAL ELECTRIC

COMPLETE LINE

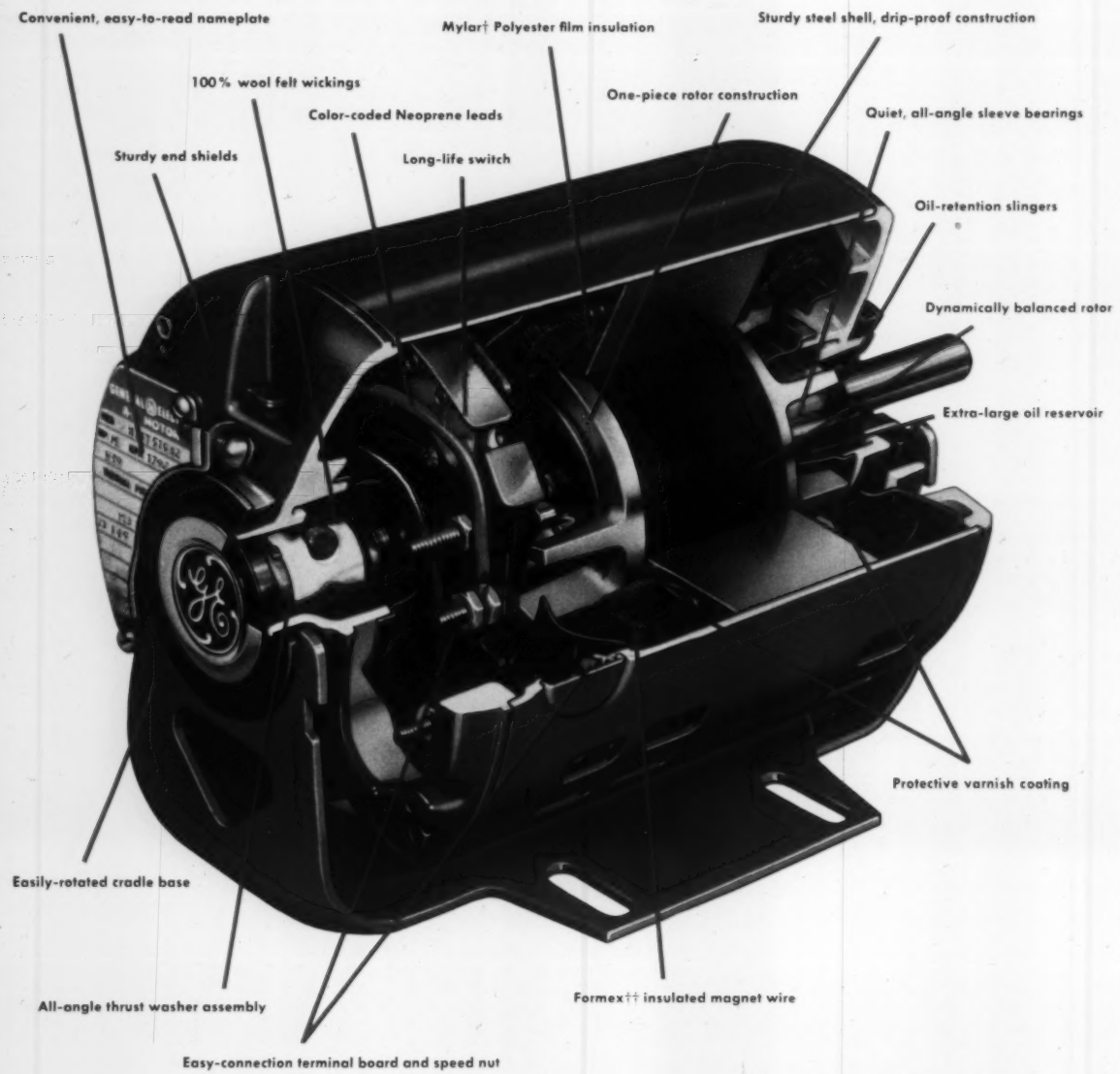
"Our broad line of exhaust fans must meet many job requirements. We found that the completeness of G.E.'s fhp motor line helped us to standardize not only on design, but ***quality***, of our products."

ALL-ANGLE MOUNTING

"Before we started producing the Moore-O-Matic door opener, we tested many motors. We chose G.E. because with all-angle mounting we could mount our unit in ***any*** position without modifications."

The General Electric "YEARS AHEAD" motor*

The motor that set a new standard . . .



*available in both 48 and 56 frames
†Reg. trademark of Dupont Co.
††Reg. trademark of General Electric Co.

GENERAL ELECTRIC

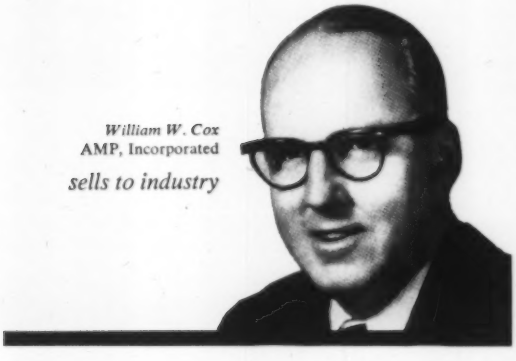
Can specialized business publication advertising actually sell?

By reputation, salesmen are reluctant to credit anything but their own selling efforts for getting names on the dotted line.

Actually, it's quite a different story. The most successful salesmen will tell you two important things about selling. 1. That the selling process is largely a matter of communicating ideas. 2. And that specialized business publication advertising can help importantly to register information with prospects.

Of course each salesman will express this in his own way . . . but they all agree that selling would be far more difficult without the advertising that appears in the industrial, trade, and professional publications that serve the specialized markets to which they sell.

Here, for instance, is what a salesman has to say about this kind of advertising:



William W. Cox
AMP, Incorporated
sells to industry

Says Mr. Cox:

"The quickest way we can introduce a product is by introducing it through advertising in business papers. That way we get it around faster than we can by word of mouth alone. On occasion my home office has inquiries out to me before I can get to the customer or prospect to introduce a new product. They've already seen it in a trade magazine.

"It's interesting to note that within the last two weeks I received a survey which shows about 80% of the new customers we get on our books come through our trade publication advertising. Of course, our company is only 15 years old and we have grown from what you might say, *nothing*, to the biggest in our business. Certainly a lot of that has come from our advertising campaigns. Our name is known throughout the world right now, purely because of our advertising program. When I go to a prospect now, they know my company, they know my product . . . it makes my job easier, and opens doors when I have to make cold calls."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable you can be sure that your business publication advertising is really helping them sell. If too many answers are negative it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful and effective package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet entitled, "How Salesmen Use Advertising in Their Selling," which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' advertising.

You'll find represented many interesting variations in how they do this. Some are very ingenious; all are effective. You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy. Then, if you decide you want to provide your salesmen with additional copies, they are available from NBP Headquarters in Washington, at twenty-five cents each. Or if you choose you can reprint the material yourself and distribute it as widely as you please. But first, send for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 4D
1413 K Street, N. W.
Washington 5, D. C. **STerling 3-7533**

Please send me a free copy of the NBP booklet "How Salesmen Use Advertising in Their Selling."

Name _____

Title _____

Company _____

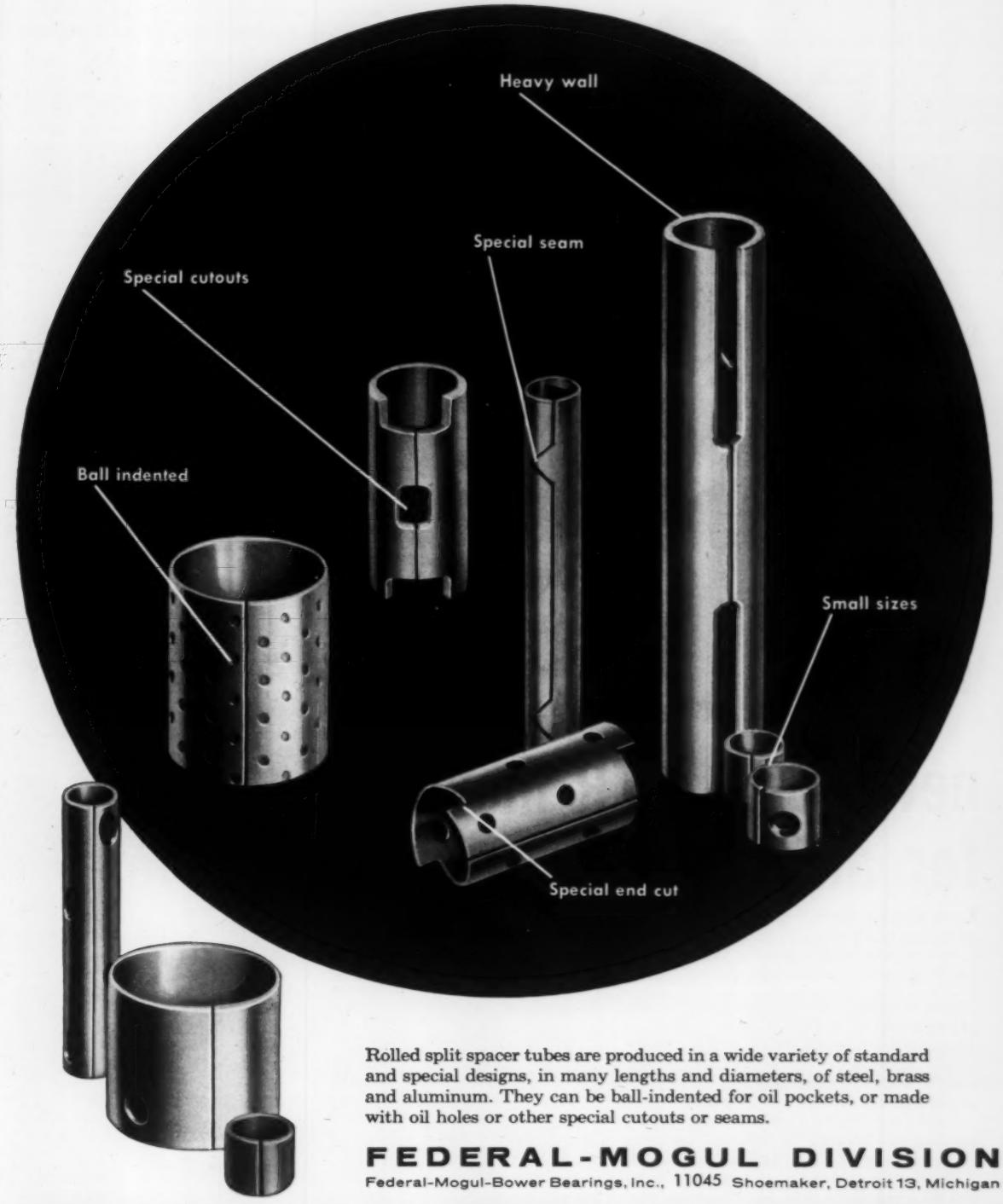
Street Address _____

City _____ Zone _____ State _____

National Business Publications, Inc.

NBP

. . . each of which serves a specialized market in a specific industry, trade or profession.

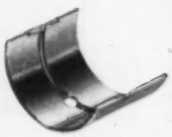


Rolled split spacer tubes are produced in a wide variety of standard and special designs, in many lengths and diameters, of steel, brass and aluminum. They can be ball-indented for oil pockets, or made with oil holes or other special cutouts or seams.

FEDERAL-MOGUL DIVISION

Federal-Mogul-Bower Bearings, Inc., 11045 Shoemaker, Detroit 13, Michigan

Rolled, Split Bushings



Engine Bearings

Bimetal Bushings

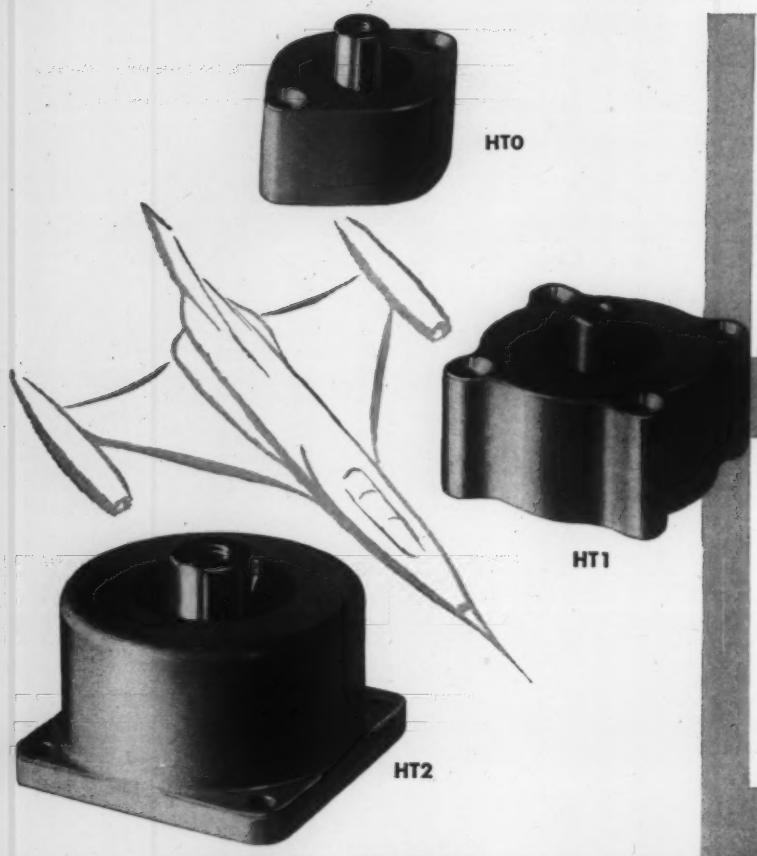
Bearing-Surfaced* Thrust Washers

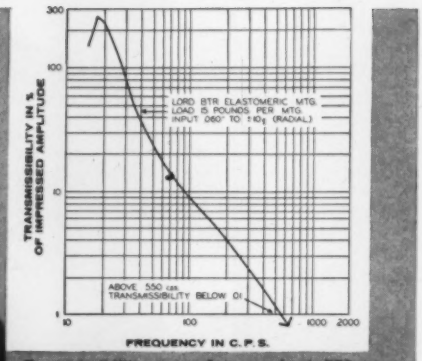
FEDERAL Mogul

Since 1889

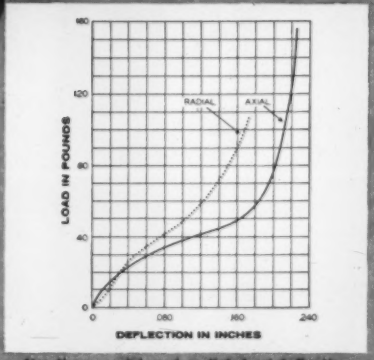
RESEARCH · DESIGN · METALLURGY · PRECISION MANUFACTURING

Circle 433 on Page 19




TRANSMISSIBILITY IN % OF IMPRESSED AMPLITUDE
LORD BTR ELASTOMERIC MTG.
LOAD 15 POUNDS PER MTG.
INPUT .060" TO 10 g (RADIAL)
ABOVE 550 cps TRANSMISSIBILITY BELOW 01
FREQUENCY IN C.P.S.

Transmissibility curve for new Lord BTR Mountings exhibits no discontinuities. Above 550 c.p.s., transmissibility is below 1%.



Non-linear axial and radial load-deflection curves show smoothly increasing shock absorption characteristics of BTR Mountings.

new LORD BTR mountings for airborne electronic equipment

LORD announces a new series of vibration control mountings for the protection of airborne electronic equipment. They incorporate LORD's new Broad Temperature Range elastomer—"BTR"—which combines performance-proved elastomeric advantages with extreme environmental resistance.

BTR Mountings provide excellent all-attitude vibration isolation of frequencies to 2000 c.p.s. under steady-state accelerations and transient shock conditions . . . with no standing waves, distributed system responses or "bottoming". Broad temperature operation is possible since transmissibility and resonant frequency remain virtually constant from −65° to 300°F.

The BTR elastomer combines three functions: load carrying, damping and snubbing. It resists oil and ozone, has high tensile strength, high tear resistance and good flex life.

The new mountings are designed in three basic sizes—HT0, HT1 and HT2—for loads from 3 to 80 pounds per mounting. Specification MIL-C-172B mounting hole configurations provide maximum interchangeability in standard military equipment.

For further details on the new BTR Mountings, consult your nearest LORD field engineer, or contact the Home Office, Erie, Pa.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-1123
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
CLEVELAND, OHIO · SHadyside 9-3175
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-8871
DETROIT, MICH. · TRinity 4-2060
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

- **provide excellent all-attitude vibration control**
- **withstand extreme environmental conditions**

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

Circle 434 on Page 19

Fafnir presents a **NEW** *series of*

MINIATURE BALL BEARINGS

featuring

1. *Vacuum melt 440C stainless steel*
2. *Balanced design*
3. *Precision tolerances*

Fafnir now offers a series of miniature ball bearings, fabricated entirely of extra clean vacuum melt 440C stainless steel. This steel has a minimum of impurities and eliminates the chances of pits and imperfections in the races.

Because of superior race finish, the ultimate results are supersensitive bearings with low torque values. The balanced construction results from separate retainers for each bearing size. Thus the pitch circle of the balls is centered between the bore and outside diameter.

Made to ABEC-5 tolerances or better, these bearings are engineered for precision instrument applications where performance and long life are vital.

Fafnir's instrument bearing division has been expanded for production of the new miniature series. These bearings are made in the world's cleanest metalworking area, regarded as a model throughout industry.

Investigate this new series of precision miniature bearings. Write for bulletin to The Fafnir Bearing Company, New Britain, Conn.

Fafnir's Precision Miniature Bearings Series currently includes four design variations available in each size.
Open Type • Two Shields
Flanged Type • Flanged Two Shields

FAFNIR
BALL BEARINGS

Circle 435 on Page 19

NEW! "Feather-touch" PUSH-to-TEST PILOT LIGHT

- Completely oil-tight, even when depressed
- Pressure connections eliminate internal wires
- Positive contact "feel" in test position
- No additional panel space required
- Choice of 6 color caps
- Full range of voltage ratings
- Mounts interchangeably with oil-tight pushbuttons and selector switches

Here's Why Square D Pushbuttons are preferred —by those who *build* machines—and by those who *buy* them

Easy to use • Square D oil-tight pushbutton operators require only a single mounting hole. Contact block terminals have pressure wire connectors for simplified wiring.

Longer lasting • Operators have all-metal construction, with anodized aluminum buttons for greater mechanical life. Melamine contact blocks with double-break silver contacts assure longer electrical life.

Wide flexibility • Any operator can be used with any contact block to meet all your requirements. Pushbuttons, selector switches, and pilot lights mount interchangeably.

Small size • Square D oil-tight pushbuttons require only a minimum of panel and back-of-panel space—and they can be mounted in any position.

Variety of contacts • Contact block arrangements include single-pole double-circuit, duplex double-circuit, tandem duplex, three-position duplex, and overlapping contacts.

• • •

FOR COMPLETE INFORMATION

on oil-tight pushbuttons, ask for Bulletin 9001-T —Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

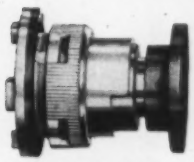
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

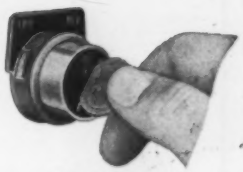
LATEST ADDITION to SQUARE D LINE of Oil-Tight Pushbuttons

OIL-TIGHT OPERATORS

Standard Button


Mushroom Button

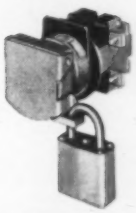
Selector Switch

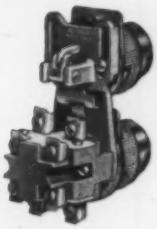

Coin-Operated Selector Switch

Key-Operated Selector Switch

Selector Pushbutton

Stop Button Lockout

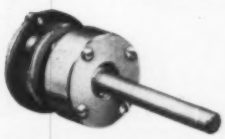

Start Button Lockout


Maintained Contact Attachment

Selector Switch and Pushbutton Lockout

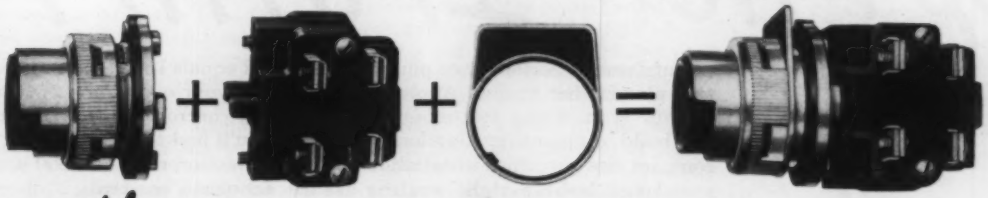
NEW!

4-Position Joystick Operator

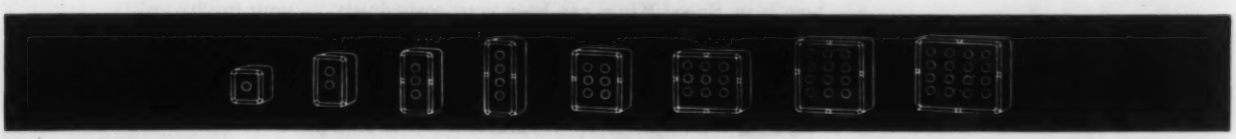

Wobble Stick Operator

Neoprene Cap

ANY OPERATOR WITH ANY CONTACT BLOCK



NEW!—*NEMA 12 Sheet Steel Enclosures Available for 6 to 25 Units*
Cast Enclosures Available for 1 to 16 Units



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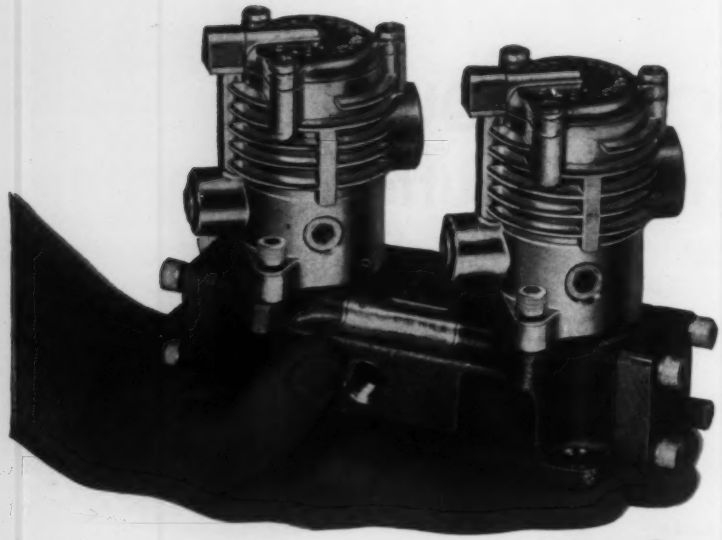
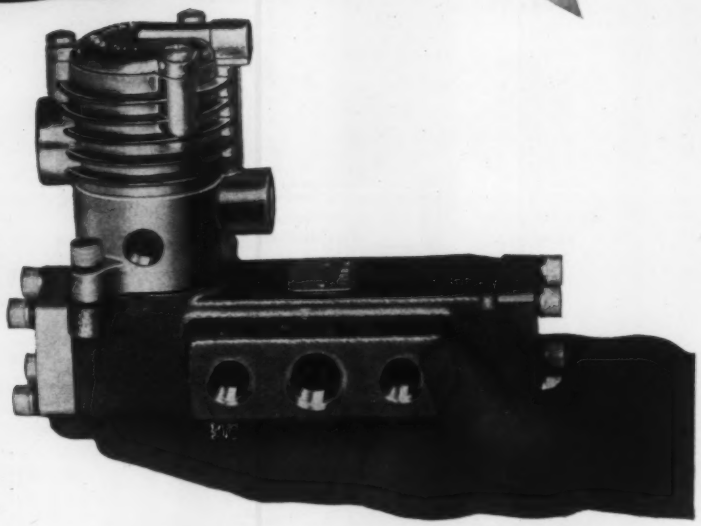


MODEL FD-120
$55.00
LIST PRICE
BASIC VALVE



MODEL F-120
$37.00
LIST PRICE
BASIC VALVE

op + lic = IPd + HPr

Outstanding performance plus low initial cost equals Increased Production plus Higher Profits! Apply this formula to your operations . . . use Valvair ¼ in. 4-way foot-mounted Speed King control valves. Whether you build or operate production machinery, you'll find that Speed King's compact size simplifies installation . . . instant-action response, 600 cpm speed and bubble-tight sealing assure accurate control . . . more productivity.

What's more, 20 million cycle-plus dependability and solenoid coils guaranteed against burn-out for the life of the valve keep maintenance and down-time at a minimum! Ask your Valvair representative to show you how ¼ in. Speed Kings can keep your costs down . . . your profits up! Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio. AA-6852

Find us fast in the 'Yellow Pages'

Compare . . . and you'll buy

Valvair

RESEARCH . . .
PROGRESS . . .
LEADERSHIP . . .

Representatives in principal cities

Circle 437 on Page 19

Cutaway section of Douglas Aircraft acoustic window used on the DC-7 below. The noise barrier is an acrylic pane (A) mounted in a foam rubber damper (B). Damper is retained in a metal pan (C). A flexible HYPALON seal (D) is compressed between the inner pane and the double thickness outer window (E). A neoprene seal (F) is cemented to the metal retainer.

Douglas Aircraft seals new acoustic window with Du Pont neoprene and HYPALON®

Douglas Aircraft has developed an improved acoustic window, designed for pressurized aircraft cabins. It is now in use on the DC-7, and a similar design will be used on the new jet DC-8. To meet the rigid demands of flight conditions, two Du Pont elastomers – neoprene and HYPALON – were selected to seal the window.

The flexible seal between the noise barrier and double pane (see D in diagram) required a resilient material with complete resistance to ozone and high color stability. In addition, the material had to show good low temperature flexibility without the addition of a plasticizer. (Plasticizers become volatile at the low pressures found at high altitudes, and condense on the window panes.)

Douglas engineers chose HYPALON because it was the only elastomer to meet these specifications. HYPALON has complete resistance to ozone. Unlike most rubbers, it can be compounded in a wide range of stable colors without sacrificing its other properties. This versatile synthetic rubber resists hardening at extreme temperatures (250° F.-350° F.) and retains its flexibility at temperatures as low as –40° F. without the use of a plasticizer.

Neoprene was chosen for the inner seal (F in diagram) because of its high resistance to ozone cracking. It retains its resilient properties in the face of heat, flexing, weather and sunlight. Neoprene is resistant to oil, chemicals, abrasion and cutting . . . and will not support combustion.

Investigate the design possibilities of Du Pont neoprene and HYPALON. Neoprene is currently used in aircraft fuel line connectors, heating system hose and cable jacketing. HYPALON is used in molded and extruded parts, fabric coating and convertible tops. For more information on the uses and properties of these versatile Du Pont synthetic rubbers, just clip the coupon below and mail today.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

ELASTOMERS IN ACTION HYPALON® • NEOPRENE

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

Circle 438 on Page 19

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

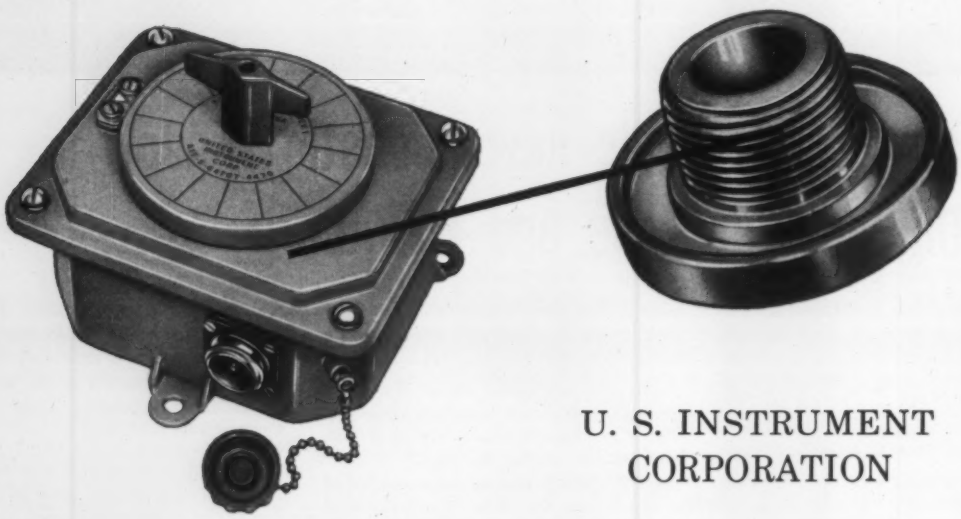
☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-3
Wilmington 98, Delaware

Name _____
Firm _____
Address _____
City _____ State _____

Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



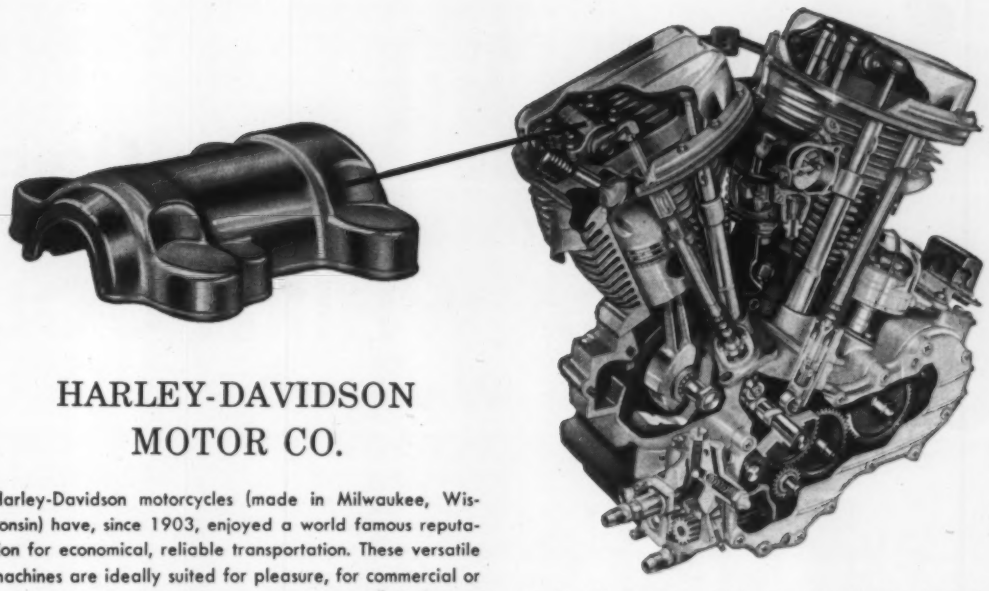
U. S. INSTRUMENT CORPORATION

U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson motorcycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings
Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563 ☐

"600" Series Bearing Alloys
Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form
Engineering Manual FM-3010 ☐

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PORT HURON 20, MICHIGAN

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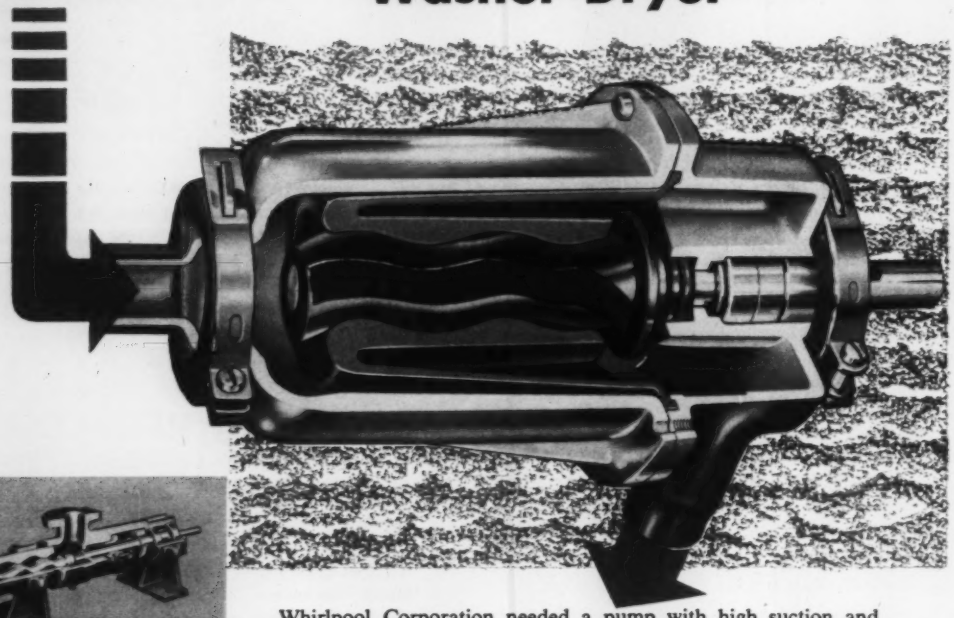
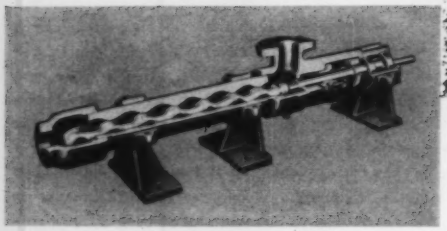
MOYNO® Pumps Oceans

(Pebbles and all) for

RCA WHIRLPOOL

Washer-Dryer





Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

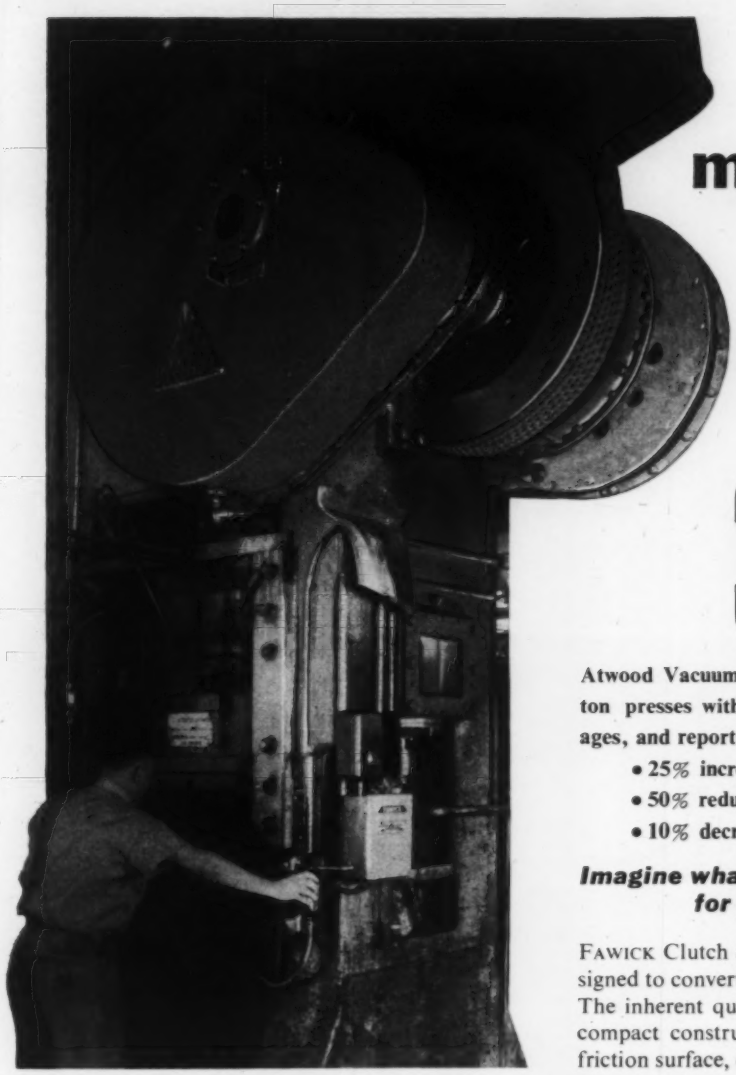
Whirlpool Corporation needed a pump with high suction and positive displacement for its automatic combination Washer-Dryer. Though sparing of water during wash-and-7-rinse cycle, each RCA Whirlpool combination circulates oceans during its long life. A Moyno Pump provides the continuous, uniform flow, 1 to 15 gal./min., free from air locking. Most important, even relatively large particles—sand, pebbles, children's pocket loot—can't stop a Moyno Pump!

In fact, Moyno's revolutionary, yet simple design can pump anything that can be forced through a pipe! A helical screw-like rotor turning inside a double-helical stator forms progressing cavities that don't squeeze . . . can't stick or gum up . . . will not cause churning, foaming . . . won't aerate or vapor-lock. On OEM products and in pilot plants, small Moynos solve pumping problems that are different, difficult or downright destructive to ordinary pumps. Write today for Bulletin—50 MD!

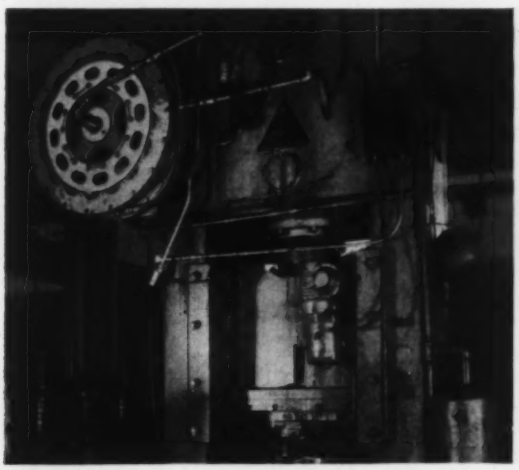
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

Circle 440 on Page 19



These two presses at Atwood Vacuum Machine Company (Rockford, Illinois) blank, shear and form hinge arms. They are equipped with Fawick VC Ventorque Clutches and Brakes, Timing Rotorseals and High Speed Clutch Controls to reduce production costs.



press modernization cuts production costs 3 ways

Atwood Vacuum Machine Company modernized two 400-ton presses with Fawick Airflex Clutch and Brake Packages, and report they realized these production advantages:

- **25% increase in crankshaft RPM**
- **50% reduction in press shutdown time**
- **10% decrease in scrap loss**

Imagine what this can do for your production costs!

FAWICK Clutch and Brake Packages are complete units designed to convert machinery to safe, high-speed production, The inherent qualities of these units—simplicity of design, compact construction, drum-type air operation with 360° friction surface, controllability and low maintenance—make them readily adaptable to all types of advanced production operations.

FAWICK'S cost-reduction record at Atwood Vacuum typifies how well these units perform their intended task. Your nearest FAWICK representative will be glad to show you the advantages of modernizing with FAWICK Clutch and Brake Packages. Or, you can contact the home office directly for more information.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto

FAWICK Airflex

INDUSTRIAL CLUTCHES AND BRAKES

Circle 441 on Page 19

ACCURATE CONTROL and high speed of response are provided by the new General Electric Speed Variator. This complete, packaged drive, including power unit, drive motor and operator's control has been designed to meet your needs for greater flexibility. The Speed Variator unit is factory assembled, wired and tested . . . ready to be connected to your a-c line.

NEW

General Electric Speed Variator

An Adjustable-speed Drive with . . .

- Amplistat® Regulator
- Static Exciter
- Kinamatic* Drive Motors
- Silicon Rectifiers
- Two-Unit, Four-Bearing Motor-Generator Set

*Trademark of General Electric Company

See how the new Speed Variator cuts costs

Progress Is Our Most Important Product

GENERAL ELECTRIC

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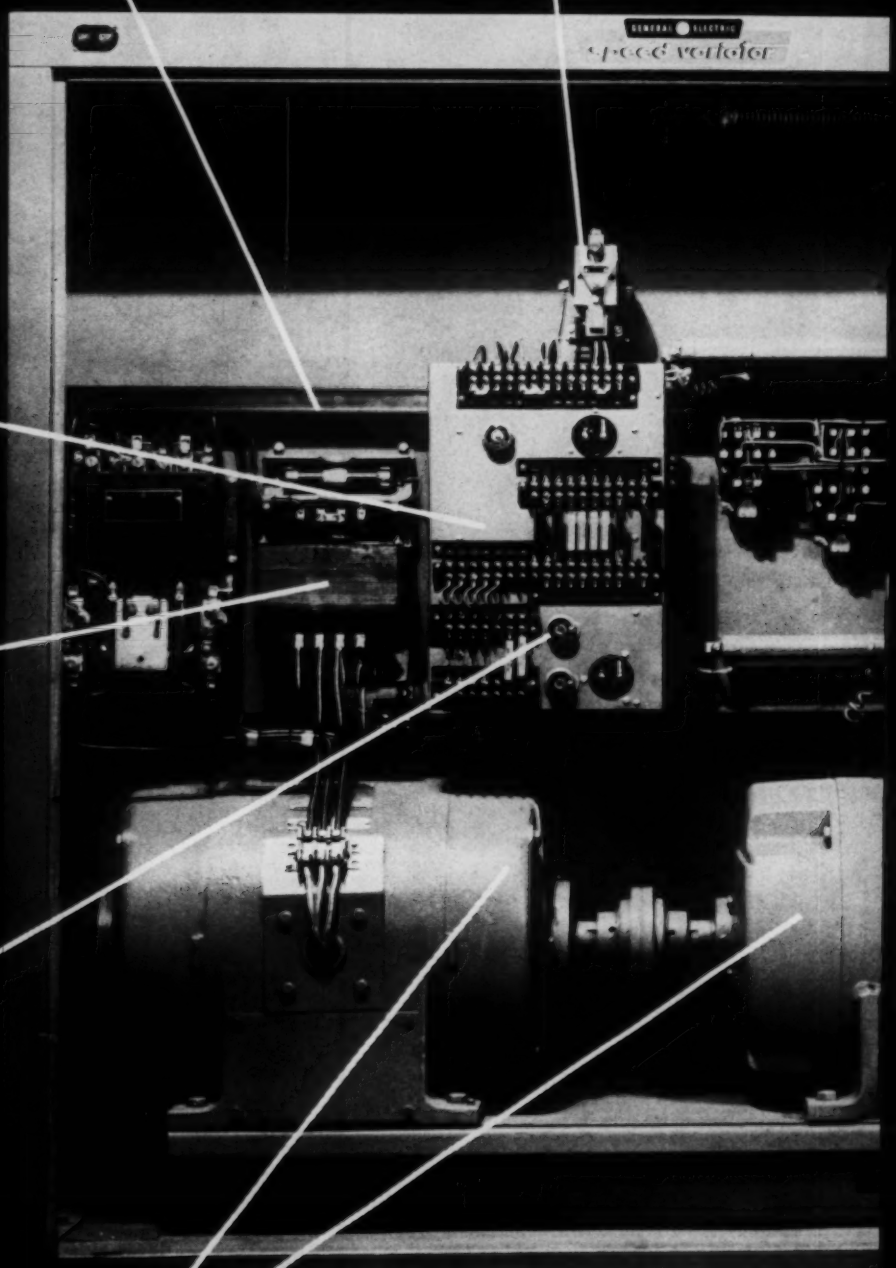
RECESSED WIRING TROUGHS simplify installation and inspection. Permit back-to-back mounting of control panels when required.

FRONT-CONNECTED CONTROL COMPONENTS make servicing and replacement easy. Standard parts can be replaced from stock.



AMPLISTAT REGULATOR is standard equipment on new Speed Variator. It holds speed steady under varying loads ... has no moving parts.

STATIC EXCITER permits immediate operation because it requires no warm-up time.

TIMED ACCELERATION AND DECELERATION permits smooth, controlled starts by means of simple potentiometer knob adjustment.

TWO-UNIT, FOUR-BEARING MOTOR-GENERATOR SET features latest design Tri-Clad† '55' alternating-current motor and direct-current generator. In ratings 3 through 50 hp, set is mounted on base in which special openings have been provided so that it can be removed by fork truck.

KINAMATIC DRIVE MOTOR can handle greater momentary loads. It provides split-second response to control signals; more power per pound and greater versatility.

NEW

SPEED VARIATOR CUTS COSTS FOUR WAYS

1. NEW AMPLISTAT REGULATOR AND STATIC EXCITER have no moving parts. Maintenance of these components is virtually eliminated.

2. LONG-LIFE SILICON RECTIFIERS are used in both regulator and exciter. Silicon offers high standards of reliability and exceptional long-life characteristics.

3. NEW DESIGN FEATURES such as front-connected control components, color-coded wiring and recessed wiring troughs, simplify inspection and routine servicing.

4. TWO-UNIT, FOUR-BEARING MOTOR-GENERATOR SET helps reduce maintenance costs. Designed with the maintenance man in mind, terminal boards and flexible coupling simplify inspection and servicing.

May we suggest you investigate the ways the new G-E Speed Variator can help you cut costs? Please contact your nearest Apparatus Sales Office or write for GEA-6643. *Direct Current Motor and Generator Department, Erie, Pennsylvania.* 813-14

Progress Is Our Most Important Product

GENERAL ELECTRIC

†Registered Trademark
General Electric Company

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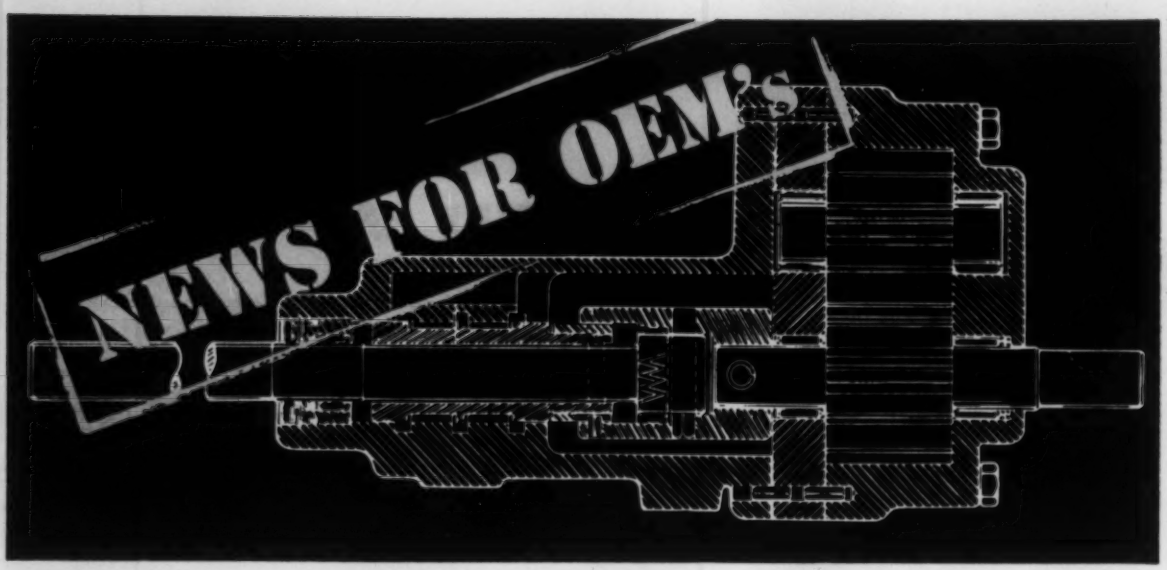


Behlen

NOW! *Expanded production makes* HYDRAULIC SERVO MECHANISM

available to MORE original equipment manufacturers

Originally known as the Behlen Powr-Steer, this advanced rotary type hydraulic servo mechanism has proved highly successful on thousands of farm tractors of many models and makes. Behlen was first to offer power steering for row crop tractors, five years ago. For the past two years, Powr-Steer has been used on a leading farm tractor line as original equipment. Demand soon outstripped our production capacity.

Now Behlen production facilities have been expanded to the point where we can offer our Hydraulic Servo Mechanism to a wide field of manufacturers of industrial heavy construction and agricultural equipment. From tractors to earth-movers. From fork-lift trucks to power shovels — every type of equipment where manual labor needs to be reduced.

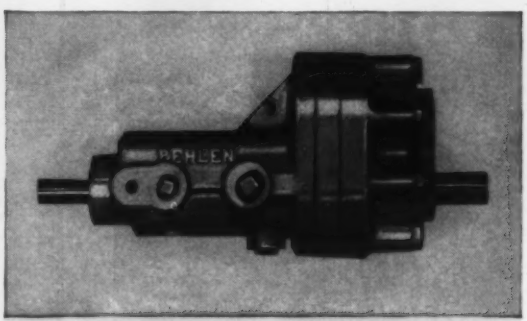
In supplying the hydraulic "muscle" of Behlen's servo mechanism to your product, you will add magic to its sales appeal.

We invite you to see how easily the Behlen Hydraulic Servo Mechanism can be applied to your products as original equipment (or as extra equipment readily installed in the field). Your request (which will not obligate you in any way) will receive the personal attention of our production manager, Howard Christenson.

Phone, write or wire

BEHLEN MANUFACTURING COMPANY
Dept. DM 3 Columbus, Nebraska

World's largest manufacturer of tractor and grader power steering



The Behlen Hydraulic Servo Mechanism, Rotary Type, Series 2000, can be used for power steering or wherever a rotary servo motion is required. Controller and actuating parts are in one compact unit, for economy and simple installation.

FULL 360° OPERATION

The Behlen unit is a gear-type hydraulic mechanism (in contrast to the piston type on passenger cars and other equipment). The power source in the unit is a gear motor that will provide continuous 360° turning under full power in either direction.

The power unit is mounted anywhere along the steering shaft. While the Powr-Steer operates as a servo mechanism between steering source and wheels, it also blocks and controls wheel shocks. Does not affect steering ratio. Maintains full and positive control through mechanical linkage in event of hydraulic power failure.

Specialized engineers in our Hydraulic Division are ready to adapt Powr-Steer to your specific needs in any of hundreds of machinery and equipment applications.

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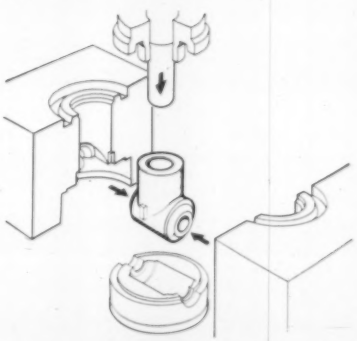
Circle 444 on Page 19→

CAMERON SPLIT-DIE FORGINGS FOR NUCLEAR POWER PLANTS

The Cameron split-die process has made ferrous forging history in components for extreme service. These AISI Type 304 stainless steel check valve bodies for nuclear power plants are another chapter in the same story. The Cameron processes were perfectly suited to produce these unusual forgings. Even though test requirements exceeded all normal procedure, we were ready to meet the exacting specifications and complete another forging contract. Most important, performance in end use could be predicted and fear of failure eliminated.

Ferrous forgings to 8,000 lbs. produced by this method emerge from our presses in near final form. A vast array of shapes and sizes, heretofore impossible to forge in one piece, are now solving knotty problems in many demanding applications.



Every single production phase from melting the high quality steels for our ingot supply through blooming, forging and heat treating to final machining is performed in our shops under constant control. Men, instruments and machines are teamed to make results predictable. Grain structures in these remarkable forgings are excellent, welds are eliminated, and machining is made easier. The result is a better component which often costs less.

Extending the design scope of ferrous forgings has made Cameron important in solving many problems which confront advanced design today. Extreme service components for airframes, jet engines, guided missiles and a wide variety of other end uses are finding a solution in the Cameron split-die forging process. If you have a problem . . . call, write or come by

Cameron
IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

INDUSTRY'S MOST ADVANCED DESIGN!

(Patent No. 2,790,882)

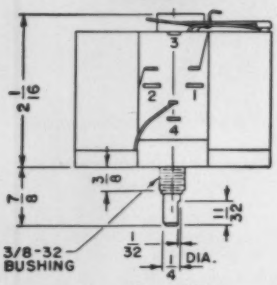
OHMITE®
V.T.
VARIABLE Transformer

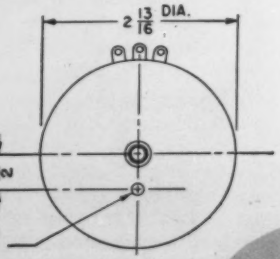
FRONT VIEW
(unmounted)

MORE CAPACITY FOR EQUAL SIZE

MODEL VT1R5—1.5 AMPERES. The rating of 1.5 amperes represents a continuous current rating at any brush setting even at full overvoltage! This "bonus" in current capacity is the result of a unique core design by Ohmite. This new component from Ohmite is made to the same high standards as the famous Ohmite resistors, rheostats, and other components. Other models in larger sizes will be announced soon.

Direct reading dial is calibrated to 120 on one side—132 on the other, for line or overvoltage connections respectively.





In addition to its greater capacity for equal size, the new Ohmite VARIABLE TRANSFORMER, representing industry's most advanced design, features the following quality features:

- *Heavily Plated Rhodium Brush Track* . . . Generous, nonoxidizing plating assures unsurpassed life under demanding conditions.
- *Positive Current Transfer* . . . The contact arm carries no current in this unit! A pigtail shunts the current from the brush, directly to a large copper-graphite slip ring which contacts a large area of the terminal. The spring-like contact arm provides its own completely independent pressure.
- *Rugged INTERNAL Stop* eliminates possibility of damage to contact arm and brush due to application of torque at rotation limits.
- *Ceramic Hub* . . . Mounts and aligns the contact arm, provides 3000 volts ac insulation between parts at line potential and shaft.

AVAILABLE FROM STOCK:
SPECIFICATIONS—MODEL VT1R5
INPUT VOLTAGE—120V, 60 CYCLE.
MAX. OUTPUT AT ANY BRUSH SETTING—1.5 AMPS. OUTPUT VOLTAGE—0-132—0-120.
ANGLE OF ROTATION—320°.
Includes knob, reversible dial plate, washer and nut.
Tandem assemblies available soon.

BACK VIEW

WRITE FOR BULLETIN 151

OHMITE V.T. VARIABLE TRANSFORMER

OHMITE® QUALITY Components

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

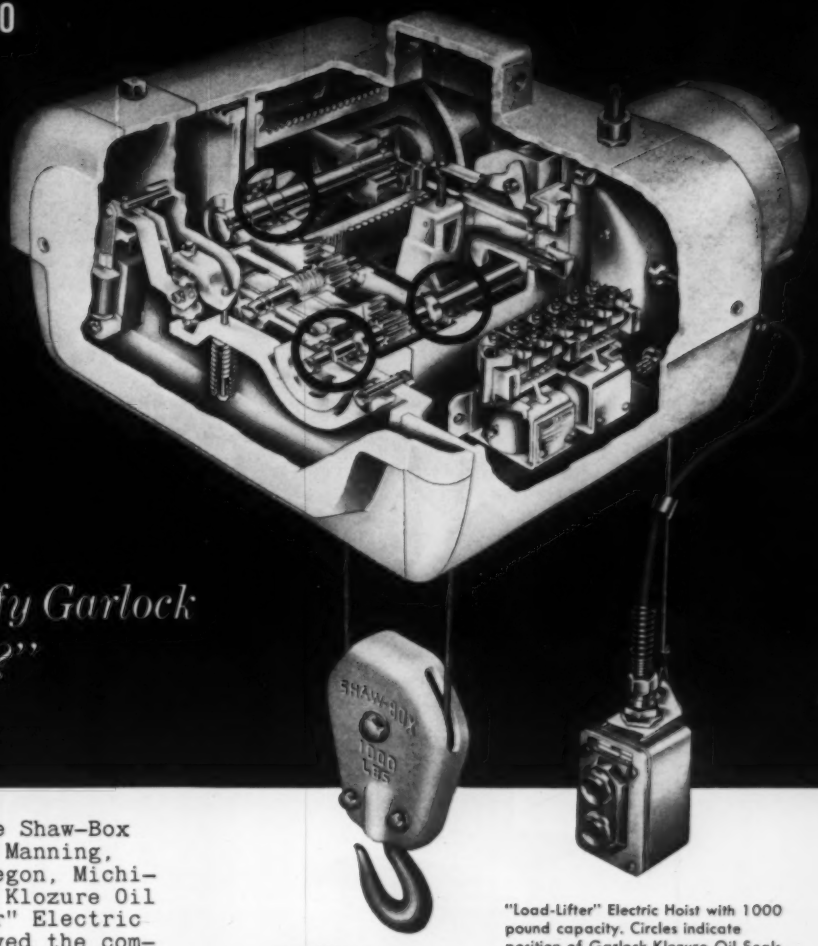
Circle 445 on Page 19

MORE OF THE GARLOCK 2,000

We Asked

MANNING, MAXWELL & MOORE:

"Why do you specify Garlock Klozure Oil Seals?"*



"Load-Lifter" Electric Hoist with 1000 pound capacity. Circles indicate position of Garlock Klozure Oil Seals.

For the past five years, the Shaw-Box Crane and Hoist Division of Manning, Maxwell & Moore, Inc., Muskegon, Michigan, have specified Garlock Klozure Oil Seals for their "Load-Lifter" Electric Hoists. Recently, we surveyed the company to find what benefits they received by specifying Garlock.

Here is their reply:

"We use Klozure Oil Seals for three primary reasons.

1. dependability. Our hoist is designed for heavy duty use. A failure in any oil seal would shortly render the hoist inoperable. Therefore, we must use oil seals consistent with the quality built into the entire hoist.
2. long-life. The oil seal must permit easy maintenance and be reusable after hoist repair since replacement of oil seals during a minor overhaul is undesirable.
3. standardization. The fact that Garlock can meet nearly every oil seal requirement permits us to attain greater standardization of hoist components."

Cross section of Model 51 Garlock Klozure Oil Seal designed for medium-speed rotary service and low pressure reciprocating service. Two of these seals are used on the motor pinion shaft and a specially designed Klozure Oil Seal on the rope drum of the Electric Hoist illustrated above.

Garlock Klozure Oil Seals can serve your company equally well. Ask your Garlock representative for his recommendation from "the Garlock 2,000" . . . two thousand different styles of packings, gaskets and seals for every need. Or write for Klozure Catalog 20.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For prompt service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

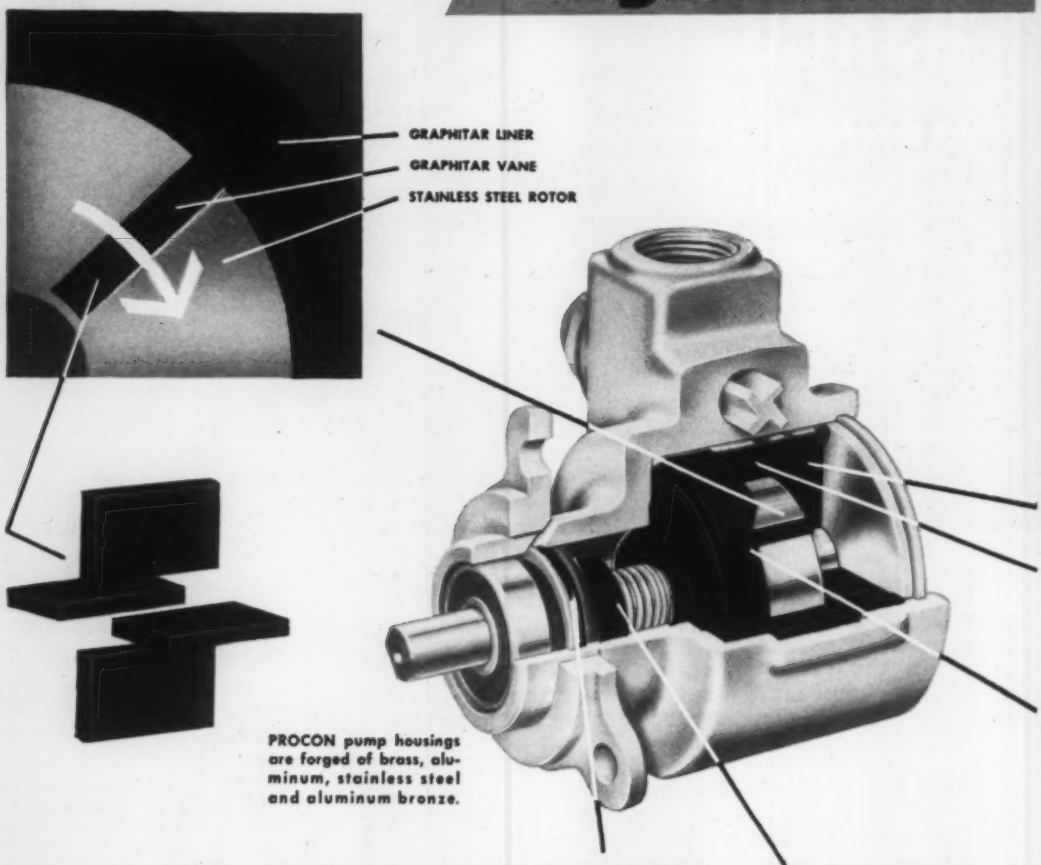
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 446 on Page 19

GRAPHITAR®

(CARBON-GRAPHITE)

against


GRAPHITAR LINER
GRAPHITAR VANE
STAINLESS STEEL ROTOR
PROCON pump housings are forged of brass, aluminum, stainless steel and aluminum bronze.
GRAMIX seal-ring retainer

GRAPHITAR is ideal for high-stress parts . . . pistons, cylinder liners, bearings and seals . . . because it's so resistant to temperature change and wear. Chemicals, concentrated acids, highly corrosive ammonia have little effect on GRAPHITAR . . . in fact, may even serve as lubricants to GRAPHITAR parts. GRAPHITAR is lightweight, can be produced economically in most any size and shape, and held to tolerances as close as .0005". Perhaps self-lubricating GRAPHITAR parts can improve the efficiency of your products. For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

THE UNITED STATES

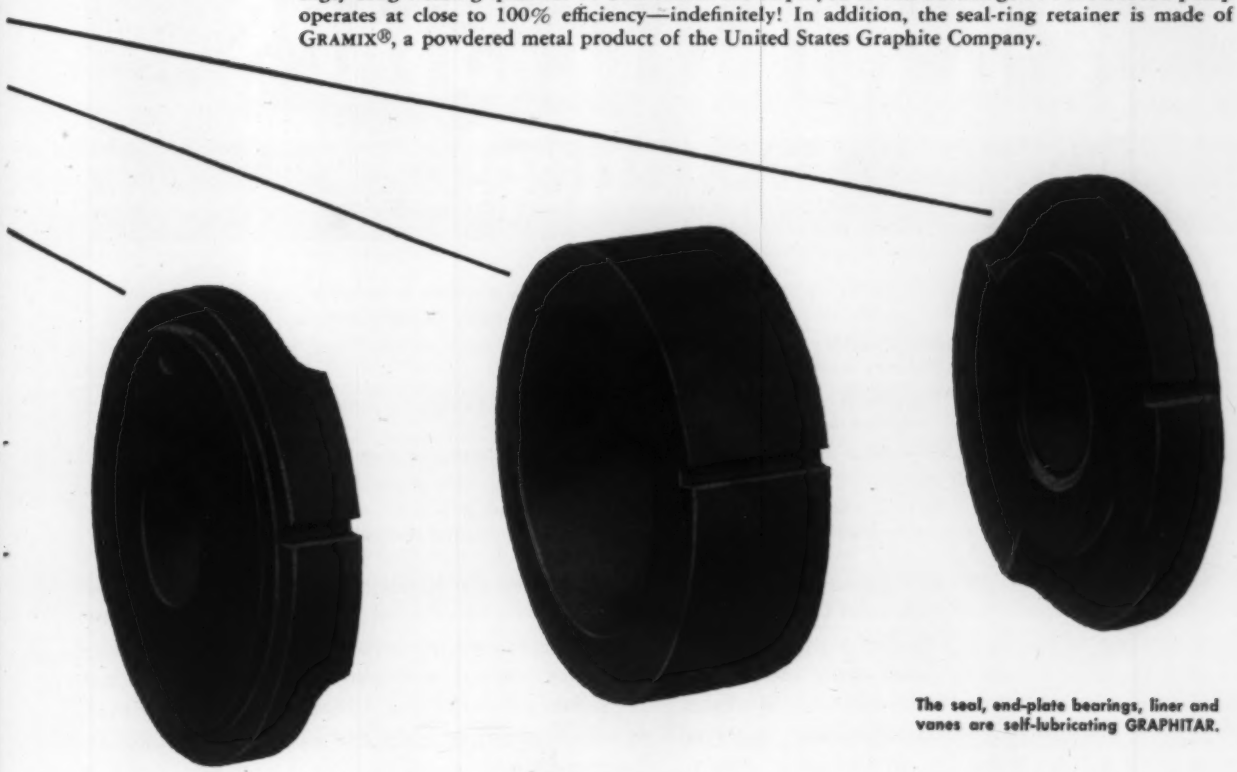
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

running GRAPHITAR®

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*

10¢ dropped in a beverage machine in Minneapolis actuates a pump that fills a paper cup with syrup and carbonated water; a Utah dentist flicks a switch that starts a vacuum pump used in molding dentures; in a manual training school in North Carolina, a pump circulates the ammonia in a blueprint machine.

Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.



The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-256-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

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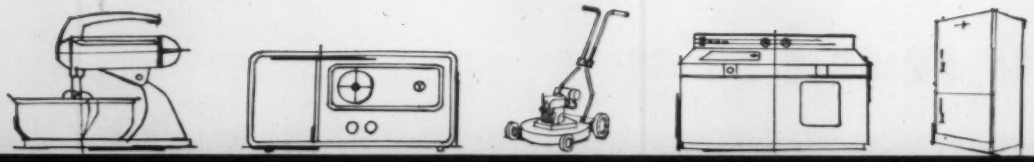
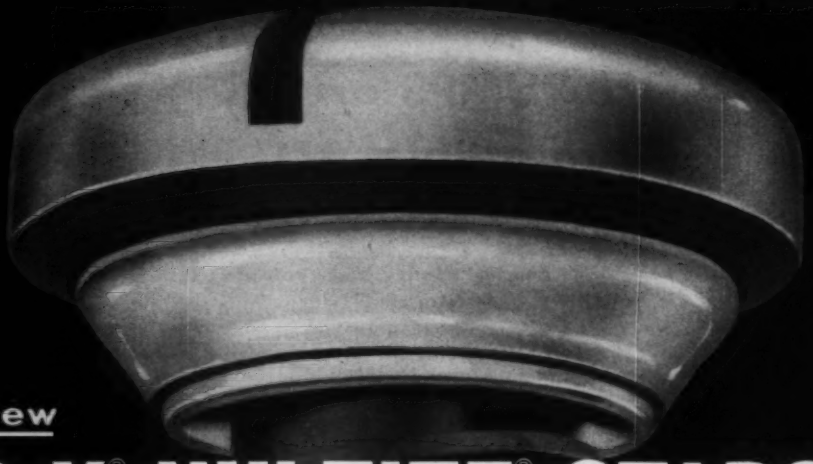


Designed especially for today's smart-styled appliances



the new

P-K® NYLTITE® STAPS®

fastener!

PROTECTS . . . Prevents cracking, chipping or crazing of costly porcelain or enameled surfaces on air conditioners, refrigerators, freezers, and similar highly finished products.

CUSHIONS VIBRATION . . . Reduces noise, prevents squeaks, leaks and electrolysis. Ideal for attic fans, power mowers, washing machines.

SEALS AGAINST LEAKS . . . against hot or cold water . . . against humidity . . . against frost creep . . . against detergents.

TRANSLUCENT . . . Made of DuPont Zytel Nylon . . . Ends color-matching problem in assembly of colored ceramic, enamel or plastic surfaces.

SECURE . . . Provides a tight, long-lasting fastening. Handsome on all exterior applications . . . Highly resistant to acids, oils and greases in interior assemblies.

New Parker-Kalon NYLTITE STAPS consist of a unique, self-conforming nylon washer made of DuPont Zytel, preassembled to standard P-K Self-tapping Screws. Won't come off in use, even in high-speed production. Eliminates time consuming hand-assembly of washer to screw. The specially designed washer is folded upon itself so that edges are on the inside circumference. When the fastener is tightened, the shank is hugged by the "controlled flow" of the nylon. NYLON ACTUALLY FLOWS INTO THE THREAD INTERSTICES, FILLS ANY IRREGULARITIES OF THE ENGAGEMENT HOLE . . . FORMS A WATERTIGHT, HERMETIC SEAL! *Furnished in a wide variety of styles and sizes. Also available in Neoprene washer styles.*

PARKER-KALON® fasteners

Sold everywhere through leading Industrial Distributors

Makers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.

SECOND ONE—
More to come

CONSIDER THESE OUTSTANDING FEATURES...

- Internal Parts—Stainless steel—give long, trouble-free service
- Coil—Continuous duty—10 watts max.—UL-approved
- Body—Forged brass—dense metal structure
- Mounting—Direct-line—can be serviced without removal from the line
- Options—Explosionproof, Manual Override, Electrical

SKINNER'S NEW 2-WAY VALVE OFFERS

big capacity — high pressure

Here's the second new line of valves designed to answer your control "puzzles." This new line, called the R Series, is a two-way, pilot-operated piston valve with ¼" orifice and ¼" NPT. It is available normally open or normally closed and operates on a pressure differential of 5 to 200 PSI. This new R Series also includes an Explosionproof line in normally open and normally closed construction. A normally closed version will be available soon to operate on pressures up to 1000 PSI.

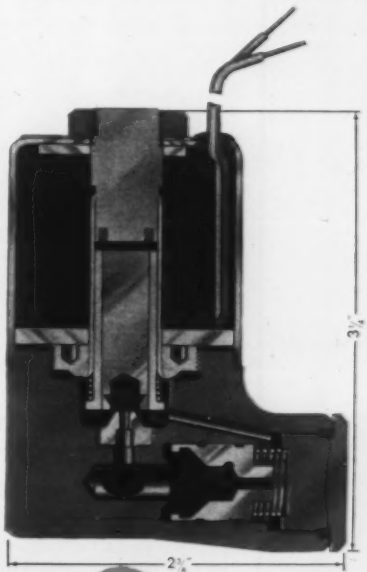
This new R Series uses the famous Skinner V5 Operator and will control air, water, oil and semi-corrosive media. The normally open version can, on request, be supplied with pilot exhaust piped to body outlet port.

A wide selection of coils—high-temperature, waterproof and standard—for common AC and DC voltages is available, and there is choice of electrical connections such as Automotive Terminals, Grommet and Conduit.

The temperature range of this new line is −65° to 180°F Ambient, and −65° to 150°F Media. It is light in weight—only 1¼ pounds—and can be mounted directly to the line by means of the ¼" NPT. Distance between ports is 2 inches.

* * *

For complete information about this new line of Skinner valves, please contact our Representative or Distributor near you—you'll find him listed in the Yellow Pages. Or write us at the address below, Dept. 423.



SKINNER ELECTRIC VALVES
THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

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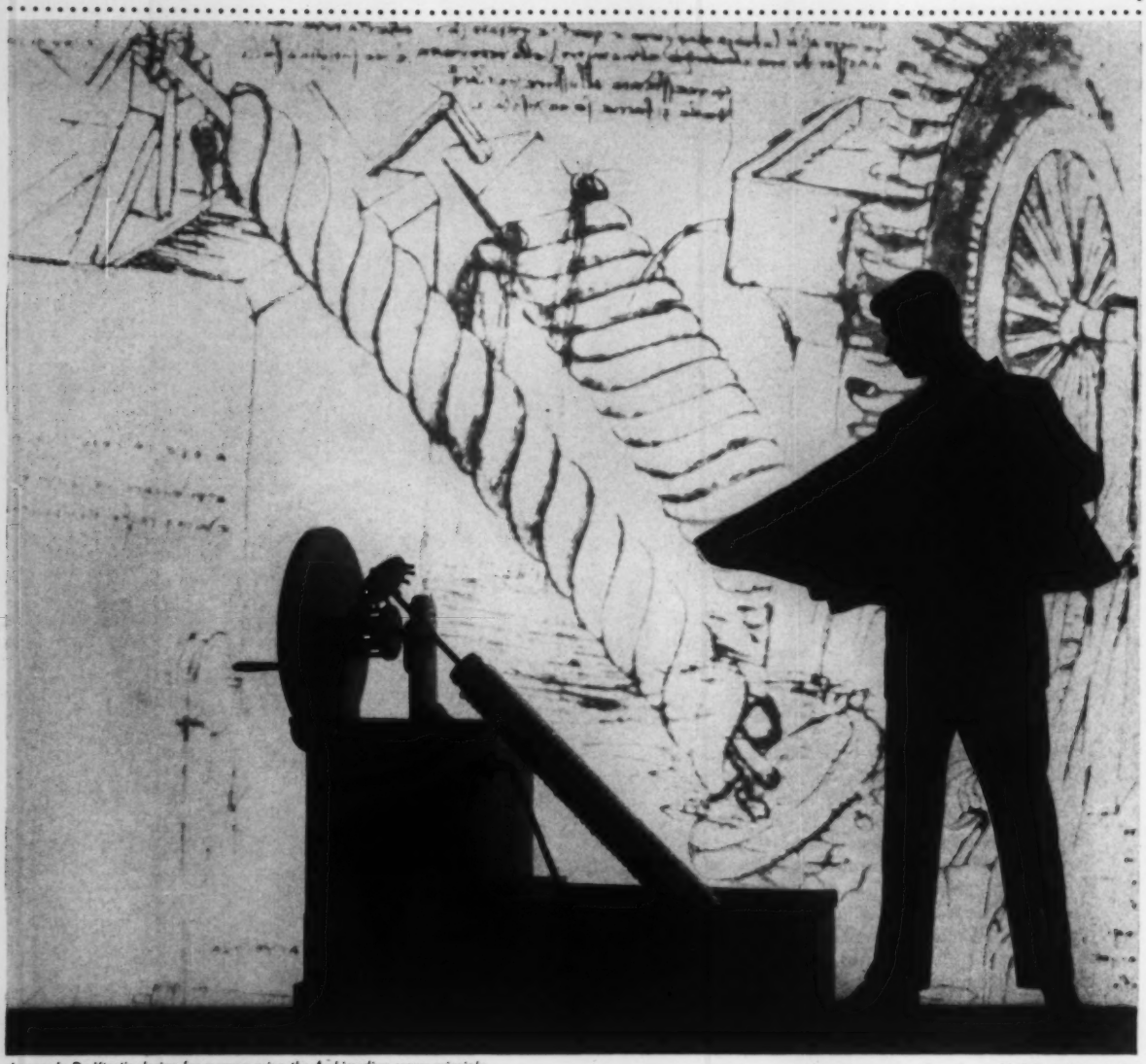
creative designing calls for an open mind

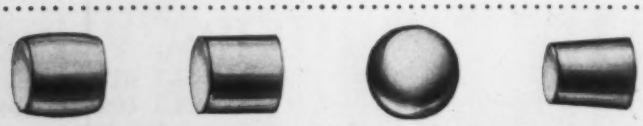


Leonardo Da Vinci's design for a pump using the Archimedian screw principle

Model courtesy of IBM

EVEN DA VINCI'S DESIGN FOR A PUMP COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

An SKF engineer never tends to favor one or two types of bearings in his recommendations. That's because SKF makes all four types of ball and roller bearings in over 3,000 sizes. This gives our engineers the kind of flexibility they need to keep an open mind on any bearings problem. Give your problem to us and see. 7822



Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

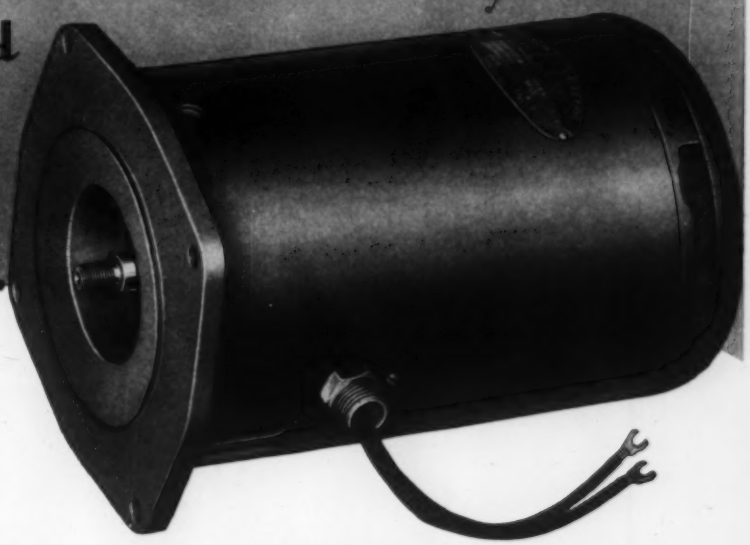
SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

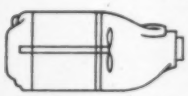
*REG. U. S. PAT. OFF

UNISEAL MOTOR *by* Franklin

...Franklineered *to improve pumps and other powered products*



CUTS ASSEMBLY TIME

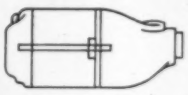


Pump impeller fastens to motor shaft, eliminating stub shaft, couplings and outboard bearings. Fewer parts, less assembly labor.

ELIMINATES ADAPTER CASTING

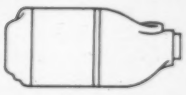
Seal cavity in end-casting enables mounting of pump without adapter casting. Reduces labor cost and parts inventory.

S/S MOTOR SHAFT IS RUSTPROOF



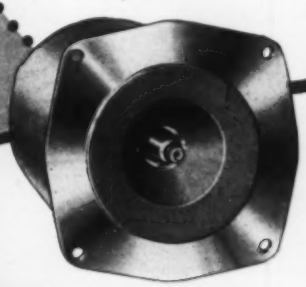
Corrosionproof stainless steel shaft guards against excess wear and seal leakage. Improves performance and longevity.

TOTAL WEIGHT IS GREATLY REDUCED



Integrated pump and motor save space and weight. Franklineering improves product appearance and performance, and cuts costs.

Precision-machined surfaces of mounting end are concentric with shaft to assure proper alignment of motor with powered product. Application-engineered to fit your products, the Uniseal Motor is available with or less base. Operates in horizontal or vertical position.



Franklineering...

describes Franklin Electric Company's advanced methods employed in design and production of application-engineered motors. Manufacturers who incorporate these motors with their products enjoy cost advantages in addition to superior performance. In the competitive water system market, leading manufacturers prefer dependable Franklineered Motors to provide product reliability.

Get the facts . . . write for Data Folder P86013

Franklin Electric Co., Inc.

345 EAST SPRING ST. • BLUFFTON, INDIANA

HOME OF DEPENDABLE ELECTRIC MOTORS

Circle 451 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

Steering column spacers are made for the Edsel by Sun Rubber Company, Barberton, Ohio. B. F. Goodrich Chemical Company supplies the Geon polyvinyl material.

GEON PART CUSHIONS SOUND

with foam in a doughnut

HERE is another new idea based on the imaginative use of Geon polyvinyl materials. It is a doughnut-shaped part at the top of the Edsel steering column.

By rotational casting of Geon materials, the part is formed with a tough, durable outer skin. Then vinyl foam made of Geon is injected into the interior cavity, to give the part resilience for sound and vibration dampening.

Colors? Geon lends itself to excellent color matching, so the part is made in the complete range of colors required by automotive stylists.

Have you a new idea

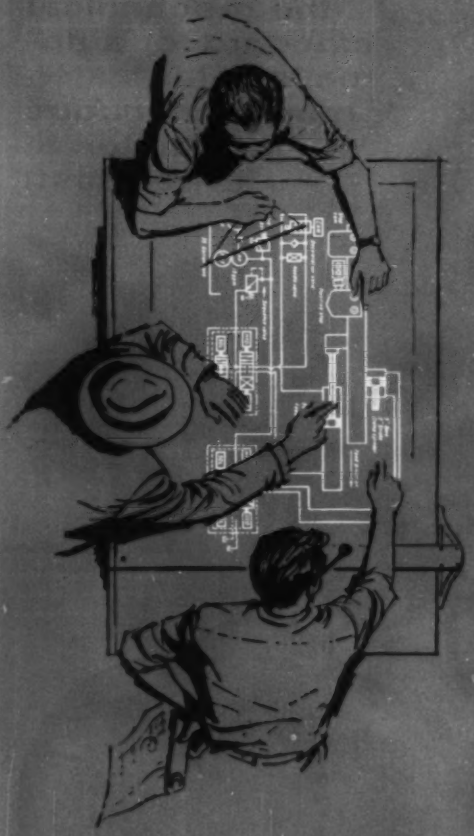
for applying plastics? Then consult B. F. Goodrich Chemical . . . we offer literally hundreds of types of Geon polyvinyl resins, compounds, latices, and polyblends tailored for different uses. For information write Dept. LO-2, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

HYDRAULICS IN YOUR NEW DESIGN?



call the man from Webster

. . . and right at the start — before design problems pyramid costs and delay production. The man from Webster is a specially trained hydraulics engineer, armed with the latest technical know-how on hydraulic power application. He'll work with you, for you, to make hydraulics serve your product better. And, chances are, one of the more than 600 Webster pumps and fluid motors will be the key to successful, efficient operation.

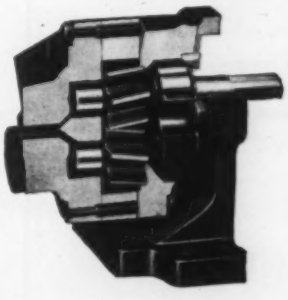
OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 3-3511
RACINE · WIS

MORE THAN 600 WEBSTER PUMPS AND FLUID MOTORS

Capacities: *1/5 to 30 GPM*
Pressures: *Up to 1500 PSI*
Speeds: *Up to 3600 RPM*
Drives: *Direct or Geared*
Torques: *Up to 60 in. lbs./100 PSI*
Available with or without built-in relief valves

H-108



☐ *Have THE MAN FROM WEBSTER contact us—*

- Please send the following -

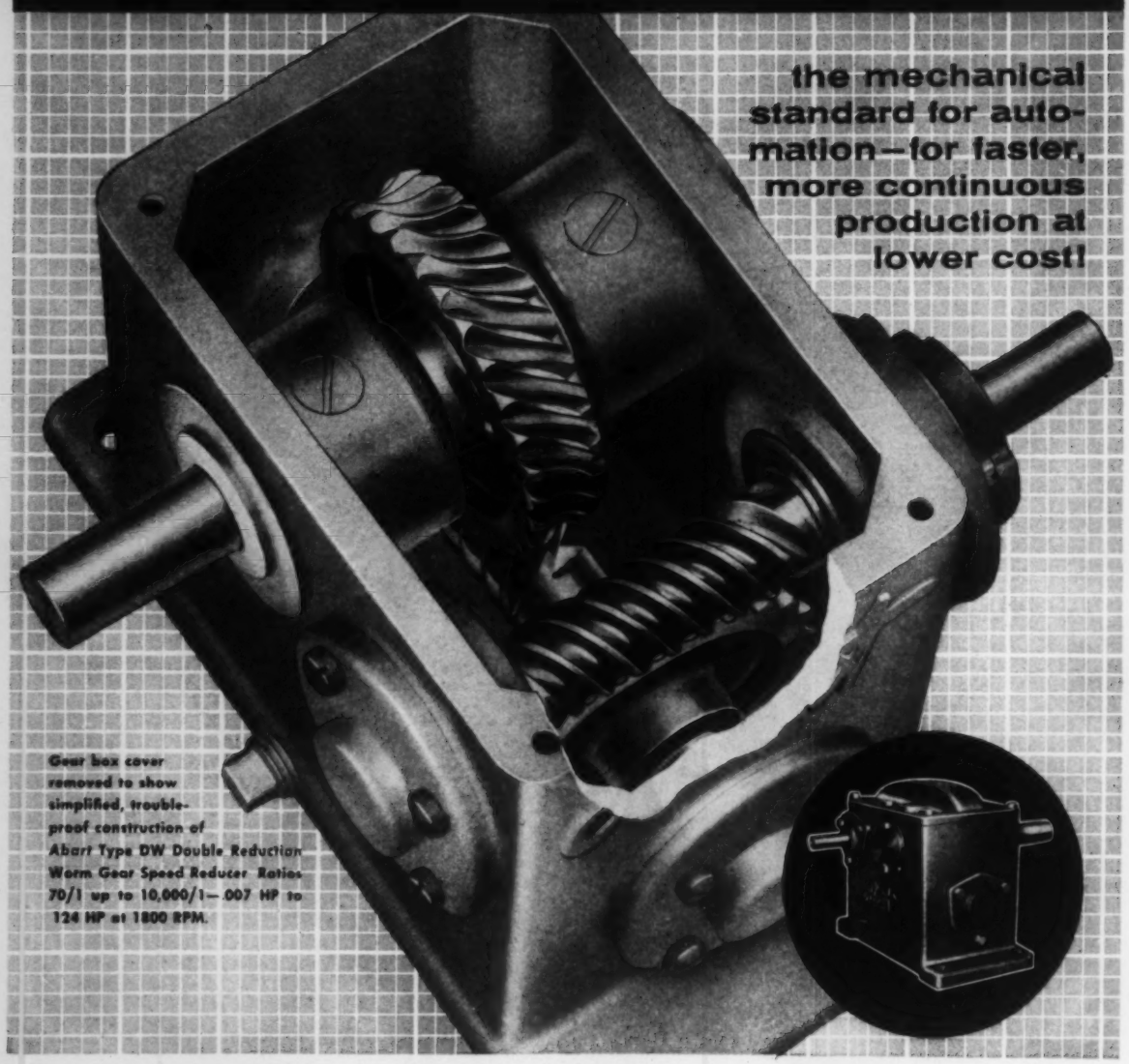
☐ *Complete hydraulic catalog of pumps and valves*

☐ *New information or data as published*

Name _____
Title _____
Company _____
Street _____
City _____ State _____

Circle 453 on Page 19

Before you decide on Speed Reducers see the *Abart* line



the mechanical standard for automation—for faster, more continuous production at lower cost!

Gear box cover removed to show simplified, trouble-proof construction of *Abart* Type DW Double Reduction Worm Gear Speed Reducer. Ratios 70/1 up to 10,000/1—.007 HP to 124 HP at 1800 RPM.

cost less to operate... cost less to maintain!

Power packaged—engineered in over 75 sizes and types—adapted to all your Speed Reducer needs within these ranges:

SPUR GEAR REDUCERS:
Ratios 2/1 up to 400/1—up to 168 HP

SINGLE REDUCTION WORM GEAR REDUCERS:
Ratios 4-5/6 to 1 up to 100/1—1/2 HP to 98 HP

COMBINATION WORM and SPUR UNITS:
Ratios 116/1 up to 2000/1—.05 HP to 13 HP

FRACTIONAL HP TYPES:
Ratios 5-4/5 to 1 up to 100/1—1/50 HP to 2 HP

DOUBLE REDUCTION WORM UNITS:
Ratios 70/1 up to 10,000/1—.005 HP to 1 HP

Pocket size—new and revised Send today for this *Abart* Speed Reducer Engineering Data Book and Catalog *Write now.*

ABART GEAR and MACHINE CO.
4821 West 16th Street
Chicago 50, Illinois

Circle 454 on Page 19

Fastener Facts

DESIGN PRODUCTION & PURCHASING DATA

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

SHOULDERED RIVETS vs MACHINED PARTS

When design calls for fasteners that also function as pivots for moving parts, it pays to consider shouldered rivets first. They may look much like screw machine parts that offer similar shoulder and tenon combinations; but the similarity ends there.

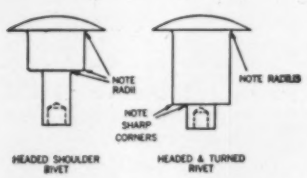
Rivets Cost Less!

Shouldered rivets cost only about half what you pay for their fully machined equivalents. That's because they can be cold-forged from solid wire in a single, high-speed operation. In most cases, no metal is removed, as with screw machine parts. So, you get all the stock you pay for.

Rivets Speed up Assembly!

Shouldered rivets are located and clinched by high-speed rivet-setting machines. Like semi-tubular rivets, they have shallow punched or drilled holes in their shanks to combine the shear and compression strength of solid rivets with low-cost fastening. On the other hand, comparable screw machine parts often require slow, costly hand locating and fastening.

Therefore, the savings in material and labor costs inherent in shouldered rivets demand their early consideration in cost reduction or value analysis programs. These low-cost, high-speed fasteners should be thoroughly investigated before designs are frozen in favor of more expensive screw machine parts.



Thomson Shouldered Rivets

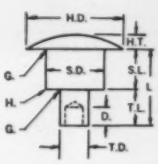
Thomson designs and produces shouldered rivets to specifications in two forms; completely cold-headed or cold-headed and turned, depending on permissible radius of corners and break of edges.

When close tolerances are not a factor as in folding baby carriages, car beds and seats, rollaway beds and comparable pivot-fastener applications, Thomson shouldered rivets are completely cold-headed . . . and, of course, priced at a minimum.

Where tighter fits are necessary, a secondary turning operation supplements the initial cold-forming to

square corners and edges to specified tolerances. Metal removal, of course is slight. As a result, these Thomson shouldered rivets cost slightly more than completely headed rivets, but much less then fully-turned parts.

Variables to Consider



In addition to permissible radius of corners (H) and break of edges (G), there are nine other design factors: head shape, the diameter (HD) and thickness (HT); shoulder diameter (SD) and length (SL); tenon diameter (TD) and length (TL); rivet length under head (L) and hole depth (D). Head shapes may be round, oval, flat, countersunk, or some special design. Because of all these variables, Thomson Shouldered Rivets are made to order after individual quotations.

Other Design Factors

It pays to think twice before you rule out shouldered rivets because of design and production consideration that seem to prevent insertion of rivet-setting machine's driver or anvil for clinching the rivets. In many cases, a slight change in spacing or cavity size allows use of rivets without changing overall dimensions. In other cases, a change in assembly sequence permits a profitable switch from costly hand assembly of expensive screw machine parts to low-cost machine-set rivets. Our engineering department, experienced in shouldered rivet applications, will be glad to offer suggestions while your designs are still in the rough-draft stage—at little or no cost.

Materials and Finishes

Thomson Shouldered Rivets are produced from aluminum, brass, copper, nickel-silver, low-carbon steel, stainless steel and other materials. They can be plated with brass, cadmium, copper, nickel, tin, zinc, etc. They can also be oxidized or finished in japanned colors to match the original equipment or end product.

Thomson High-Speed Machines

The inherent economy of shouldered rivets as pivot-fasteners is multiplied by high-speed assembly made possible by automatic rivet-setting machines which can be operated by unskilled labor. Thomson, inventor of the first automatic-feed rivet-setting machine, has developed more than 250 styles which can do thousands of fastening jobs . . . with or without adaptations. Multiple rivet-setting heads, special work handling and loading fixtures are optional features that further accelerate assembly operations. Thomson will select and custom tool the proper machines to speed assembly and reduce costs in your plant. You can either buy or lease them and Thomson's sales-service engineers are available to keep them in top operating conditions.

TYPICAL RIVET-SETTING MACHINES

FLOOR-TYPE FOOT-OPERATED

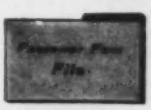
FLOOR-TYPE MOTOR-OPERATED

Design and Engineering Service

Contacted while designs can still be modified, we will analyze your pivot-fastening problems and tell you whether shouldered rivets are best for you . . . at your request. Send sketches or prints, if samples are not available.

Free "Fastener Fact File"

Be one of the first to profit from our new manual on all phases of riveting. It covers rivet types, applications, materials, finishes and other factors that determine selection of the right rivet design and machine for cutting fastening costs. Request your copy today. Write: Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Mass.



JUDSON L. THOMSON MFG. CO. WALTHAM 54, MASS.

See us at Booth 308 at the Design Show

Eastman

HIGH PRESSURE ASSEMBLIES

for

Responsive POWER

INSTANT response means extra POWER. Improving the "Power-Performance Ratio" of your equipment may mean an extra bucket per minute, extra tons per hour, extra loads per day.

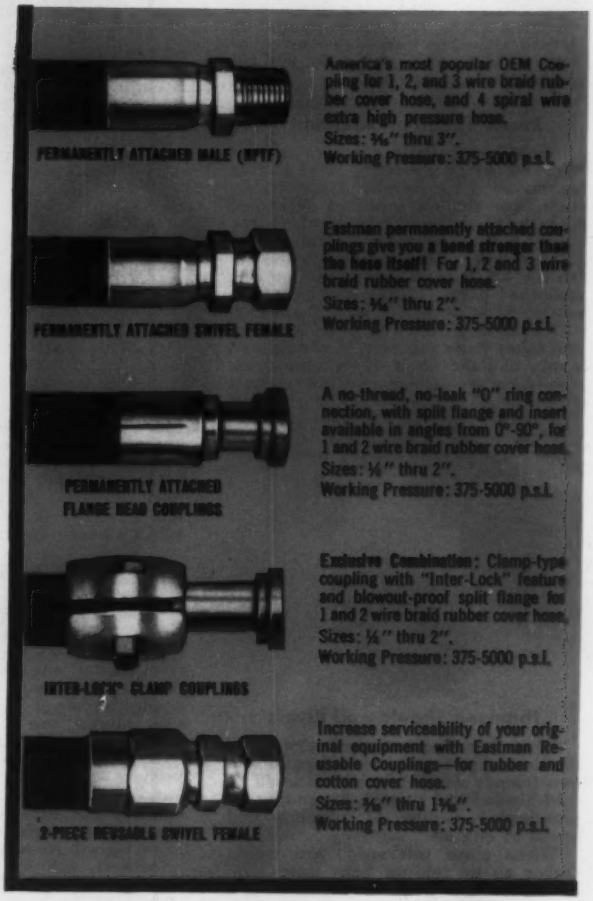
With the increasing emphasis on POWER, it pays to safeguard the most important link in your hydraulic system with Eastman *High Pressure* Hose and Tube Assemblies.

Eastman Coupling Design gives you maximum orifice, consistent with essential safety and strength, to provide "trigger-response" through unrestricted flow from pump to point of work—plus prompt return.

BENT TUBING TO YOUR SPECIFICATIONS

Eastman's modern, hydraulically-controlled tube bending equipment provides bent tubing to your precise specifications—made with flared or beaded ends for your required fittings. Quality workmanship assures satisfactory performance. Mass production economies assure competitive quotations.

For positive power delivery and efficiency throughout your hydraulic system—plus appearance and sales appeal—it pays to specify Eastman High Pressure Hose and Tube Assemblies for your original equipment.


PERMANENTLY ATTACHED MALE (NPTF)
America's most popular OEM Coupling for 1, 2, and 3 wire braid rubber cover hose, and 4 spiral wire extra high pressure hose.
Sizes: ¼" thru 3".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED SWIVEL FEMALE
Eastman permanently attached couplings give you a bond stronger than the hose itself! For 1, 2 and 3 wire braid rubber cover hose.
Sizes: ¼" thru 2".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED FLANGE HEAD COUPLINGS
A no-thread, no-leak "O" ring connection, with split flange and insert available in angles from 0°-90°, for 1 and 2 wire braid rubber cover hose.
Sizes: ½" thru 2".
Working Pressure: 375-5000 p.s.i.
INTER-LOCK® CLAMP COUPLINGS
Exclusive Combination: Clamp-type coupling with "Inter-Lock" feature and blowout-proof split flange for 1 and 2 wire braid rubber cover hose.
Sizes: ½" thru 2".
Working Pressure: 375-5000 p.s.i.
2-PIECE REUSABLE SWIVEL FEMALE
Increase serviceability of your original equipment with Eastman Reusable Couplings—for rubber and cotton cover hose.
Sizes: 5/16" thru 1¼".
Working Pressure: 375-5000 p.s.i.

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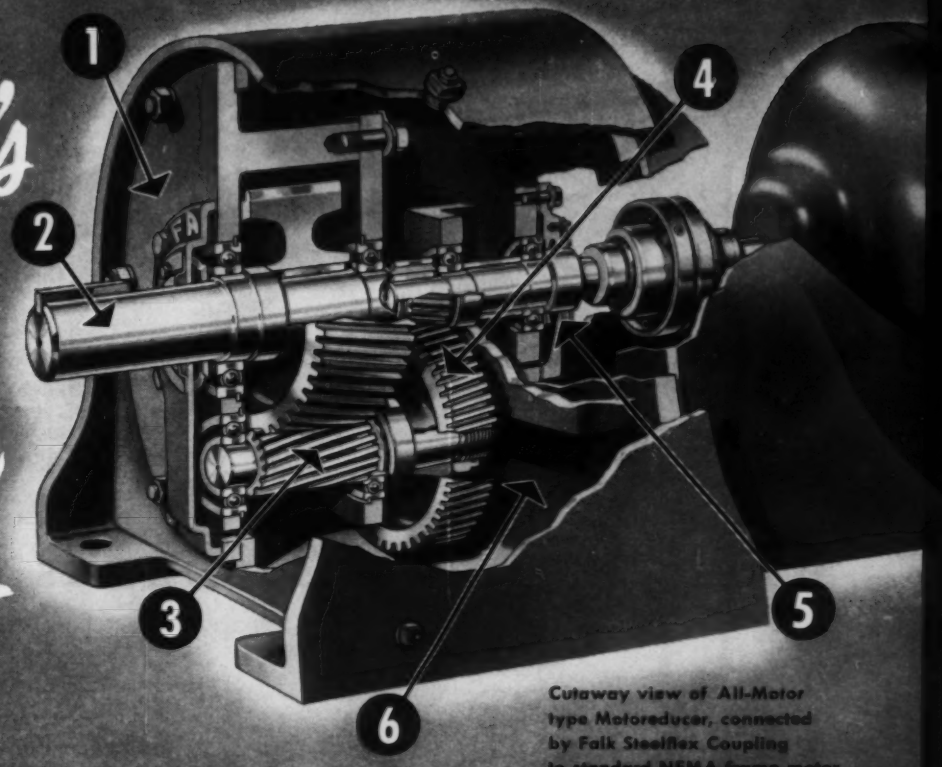
WRITE FOR HIGH PRESSURE CATALOG!
Get on our mailing list to receive out latest Technical Bulletins, Catalogs and Special Inserts.

Here's the inside story—



Cutaway view of All-Motor type Motoreducer, connected by Falk Steelflex Coupling to standard NEMA frame motor

WHY Falk Motoreducers give better service—have longer life

Here is the "inside story" behind the all-steel All-Motor type FALK Motoreducer's universal reputation as a gear drive unmatched in quality, efficiency, dependability, ease of maintenance and long life. These "In-built" factors are—

1 **ALL-STEEL HOUSINGS.** Rugged, strong, rigid...all parts are manufactured from heavy steel plate, formed and welded in the Falk Weld Shop.

2 **LARGE OVERHUNG LOAD CAPACITY.** Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum applied loads.

3 **PRECISION GEARING.** Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion. Quiet, crown-shaved pinions.

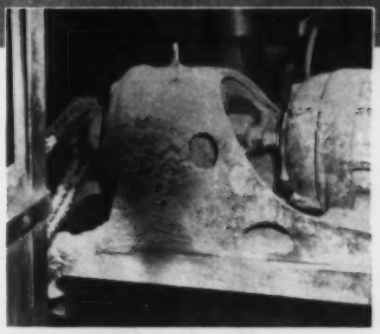
4 **EXTRA-CAPACITY GEARING.** Special extra-capacity gear-tooth form with larger contact area gives greater strength, higher load-carrying capacity.

5 **SEALED HOUSINGS.** Splashproof, dustproof, oil-tight construction. Dual closures and one-way vents keep oil in, dust and moisture out.

6 **POSITIVE LUBRICATION.** Large sump capacity...oiltight construction assures clean lubricant...revolving elements lubricated by direct dip.

When you buy or specify the All-Motor type FALK Motoreducer, you get all these—plus the tremendous advantage of full interchangeability of motors. Switch motors as desired—use any make, style or type of standard foot-mounted motor within the unit's AGMA rating—with a minimum of difficulty or "down time."

Available in sizes up to 75 hp—*with or without motor*—from convenient factory, field or distributor stocks, from coast to coast. **Write for Bulletin 3100.**



60,000 HOURS WITHOUT A FAILURE!

Sixty thousand hours is a lot of hours—but the FALK Motoreducer in the unretouched photo above has served that long without failure or need of repair.

This 3 hp unit is one of over 60 FALK Motoreducers in daily service in an Eastern plant of a large milling company, whose president says, in part:

"One of the main advantages of FALK Motoreducers is their adaptability to any motor. Reducers and motors can be easily interchanged.... Our service records confirm the wisdom of our choice of FALK equipment as our standard."

FALK ...a good name in industry

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

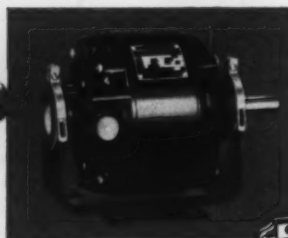
Circle 457 on Page 19

When Timing Is Important

Emerson-Electric is ready to help you *right now* with any power-drive problem. In your highly competitive business, tomorrow can be too late. Skilled specialists who know motors and the needs of appliance and equipment manufacturers are always ready to go to work for you. They'll start with your design ideas—follow through to production and tested performance.

It is this on-the-spot service, plus more than 65 years' experience meeting motor-drive requirements, that have made Emerson-Electric motors foremost in appliance applications.

Call, wire or write Dept. M-106 today.
The Emerson Electric Mfg. Co., St. Louis 21, Mo.



Every Emerson-Electric motor is custom-engineered to meet your exact requirements.

EMERSON-ELECTRIC

of St. Louis *Since 1890*

(Advertisement)

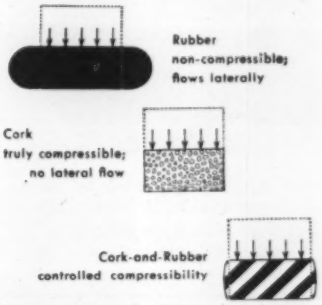
Technical data for gasket design and selection

NUMBER ONE

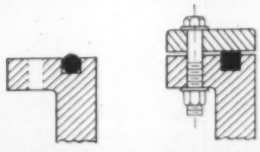
How to cut the cost of O-rings

Molded rubber O-rings are incompressible and therefore must be made to close tolerances to fit perfectly between the flanges. An O-ring too small in cross-section will not seal effectively . . . oversize O-rings prevent flange contact.

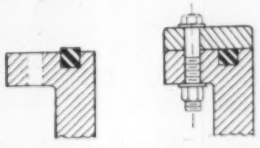
Inexpensive lathe-cut rings of re-



silient cork-and-rubber combine the compressibility of cork with the incompressibility of rubber. A controlled



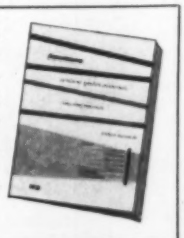
O-rings made of straight rubber compounds are incompressible; if they're even slightly oversized, the joint will not close.



Cork-and-rubber rings are compressible and may be cut to full channel width and from 20–33% deeper than the channel.

compressibility range of from 20% to 33% can be achieved, eliminating the need for close tolerances.

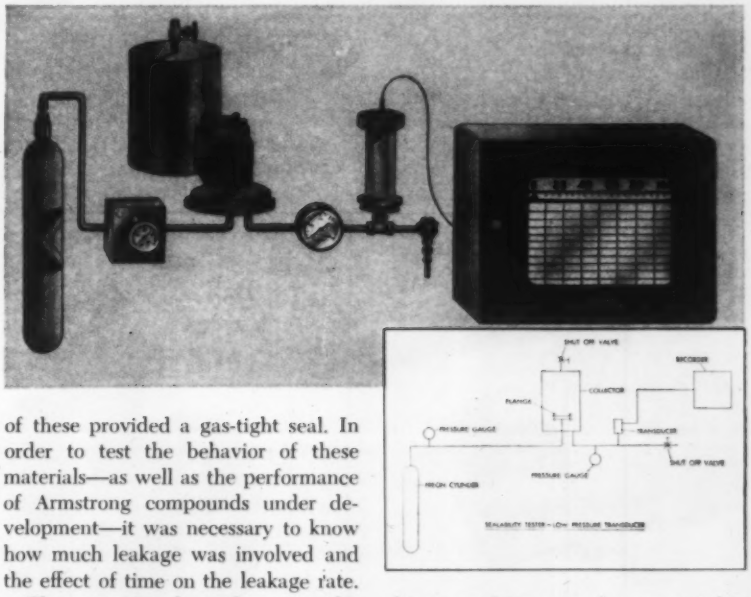
For your free copy of this new booklet, write Armstrong Cork Company, Industrial Division, 7103 Dean St., Lancaster, Pa.



Testing the sealing characteristics of refrigeration compressor gaskets

Sealing a refrigeration compressor can be a tough gasket problem. The effects of elevated temperature and high internal pressure are aggravated by the tendency of refrigerants to attack some gasket materials.

In developing an improved gasket for compressors, Armstrong research engineers tested commercially available materials. They found that none of these provided a gas-tight seal. In order to test the behavior of these materials—as well as the performance of Armstrong compounds under development—it was necessary to know how much leakage was involved and the effect of time on the leakage rate.



The apparatus shown here provides such information. FREON* refrigerant under 128 psi at 72° F. is piped to a gasketed compressor flange covered by a sealed collector. Leakage is sensed by a transducer as an increase in pressure in the collector. The increases are continuously recorded.

With this apparatus, the effect on gasket materials of such gases as FREON refrigerant can be observed and evaluated. As one example, it is known that this gas has a pronounced swelling effect on unconfined samples of gasket materials that contain nitrile-type rubber. In this device, however, materials are tested under normal compression, and tests show that the swelling effect of the FREON improves the sealing efficiency of the gasket.

As a result of such testing, Armstrong has developed a new high-density asbestos gasket material—Accopac AN-890. This new product seals better than some conventional materials, and it offers a cost saving of from 15% to 30%.

At Armstrong, research on problems of gasket design, selection, and performance is a full-time activity. This work may be of help in solving a sealing problem for you. We'll be glad to make recommendations if you send details to us.

*FREON AND COMBINATIONS OF FREON- AND F- WITH NUMERALS ARE REGISTERED TRADE-MARKS OF THE E. I. DU PONT DE NEMOURS & CO., INC., FOR ITS FLUORINATED HYDROCARBON REFRIGERANTS.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

Circle 459 on Page 19

Rockwood Ball Valves

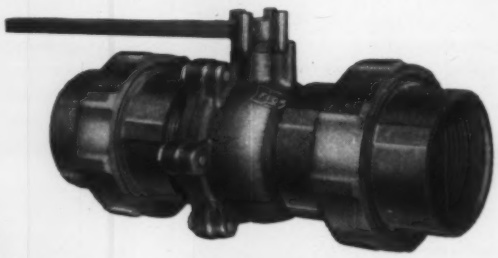
- *Full round pipe size flow*
- *Leakproof service*
- *¼ turn opening and closing*
- *No maintenance*

Air-Operated Ball Valves

For remote control use

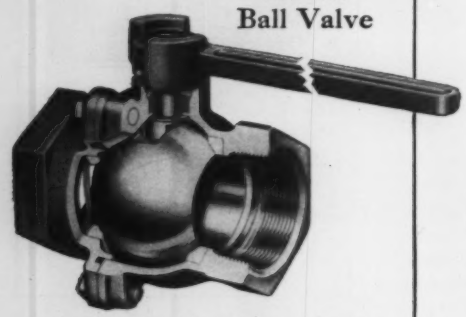
Controls valves in hazardous or hard-to-get-at places . . . can be mounted in FOUR different positions around the Rockwood Ball Valve...several can be controlled from one control board...available in a complete package unit from your distributor.

Male Thread Bronze Ball Valve



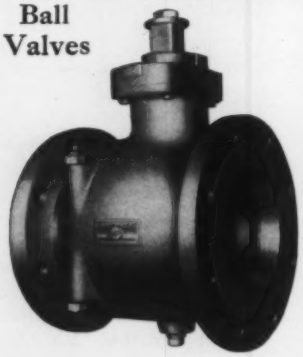
Full flow . . . with thread end, flanged end, union end or combination of same available with this valve. Longer life . . . greater strength. Size 2½" only.

Steam Ball Valve

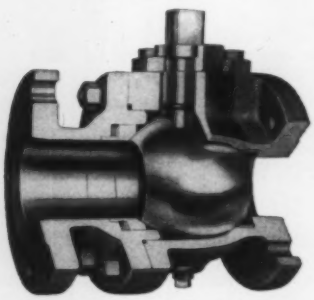


New Rockwood Ball Valve for use with steam handles up to 125 pounds of steam per square inch and 350 degrees F, with ease . . . opens and closes quickly. Pipe sizes ⅜" to 2".

6" and 8" Cast Steel Ball Valves



3" and 4" Cast Steel Ball Valves



Combines best features of plug cocks, gate and globe valves . . . made of medium carbon cast steel that meets specifications for carbon steel pressure castings as embodied in ASTM. Also made in other materials.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Write for complete data to Rockwood Sprinkler Company, 2170 Harrow St., Worcester 5, Mass. Distributors in all principal industrial areas.

ROCKWOOD

Tested and listed by Underwriters' Laboratories, Inc.

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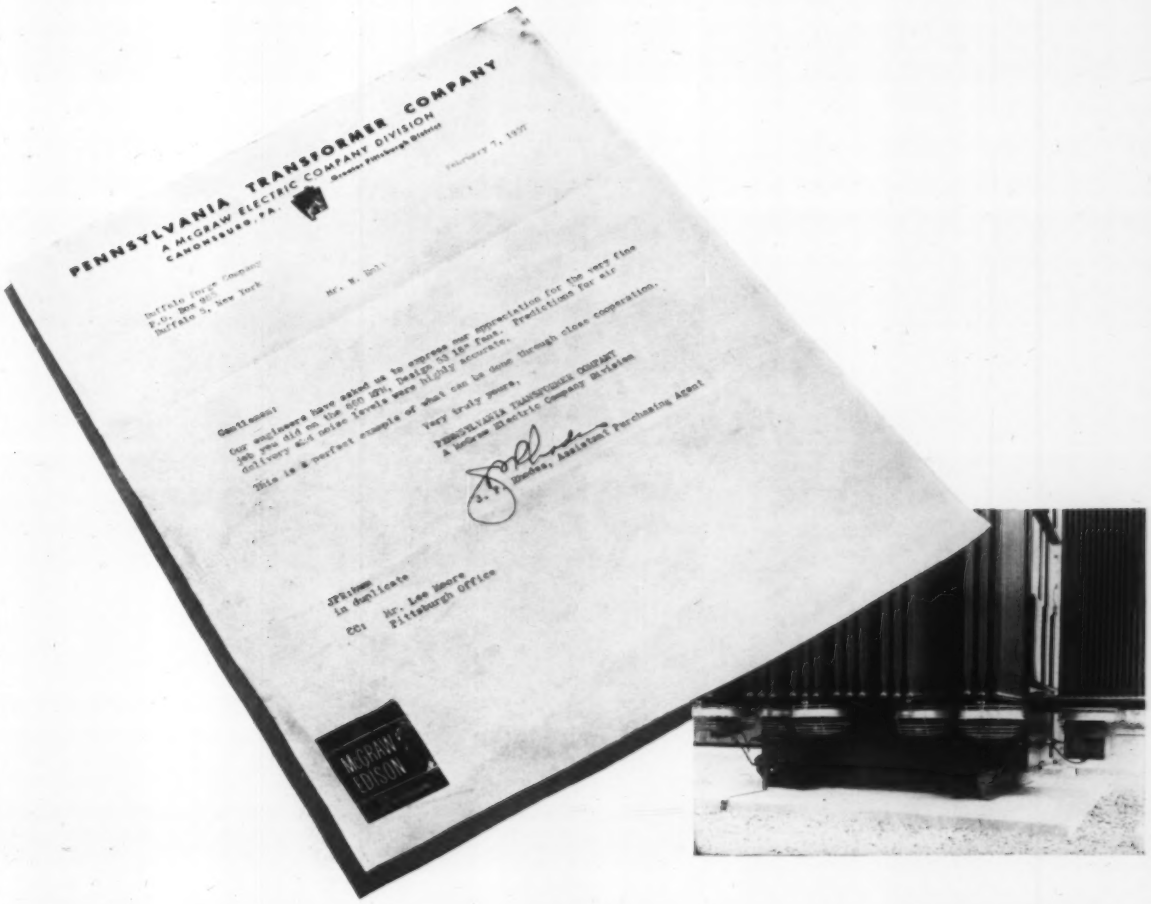
PENNSYLVANIA TRANSFORMER COMPANY
A McGRAW ELECTRIC COMPANY DIVISION
CANONSBURG, PA.
Gentlemen:
for engineers have asked us to express our appreciation for the very fine
job you did on the 500 HP, Design 53 Fan. Predictions for air
delivery and noise levels were highly accurate.
This is a perfect example of what can be done through close cooperation.
Very truly yours,
PENNSYLVANIA TRANSFORMER COMPANY
A McGraw Electric Company Division
Purchasing Agent
In duplicate
Mr. Lee Moore
Pittsburgh Office
McGRAW EDISON

ACCURATE FAN PERFORMANCE IS NO ACCIDENT!

The above comments typify the satisfaction received by users of "Buffalo" Air Moving Equipment. They point to the outstanding job performed by the "Buffalo" Fans on this installation. Of equal importance, it also speaks highly of the acknowledged ability of "Buffalo" Engineers to make sure that the fans they recommend will do the job they're required to do . . . and do this job better than any other fan.

Multiple-unit installations of "Buffalo" Fans have been specially-engineered to perform the exacting job of quietly cooling Pennsylvania Transformers to insure reliable and uninterrupted service. Pictured is a typical installation at the Long Island Lighting Company, Hicksville, New York.

Flexible and versatile, these dependable fans are quietly and efficiently ventilating equipment of all types, and plant areas ranging from a single room to large buildings. They provide economical, compact, easy-to-install packaged units in capacities from 500 to 250,000 cfm.

Think of "Buffalo" Fans in terms of the jobs they can be doing *better . . . at lower cost . . .* for you. Investigate them *now*. Contact your nearest "Buffalo" Engineering Representative.

"Buffalo" Fans feature the famous "Q" Factor — the built-in Quality that means trouble-free satisfaction and long life.

"Buffalo"

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd. • Kitchener, Ont.

VENTILATING • COOLING • HEATING • AIR TEMPERING • PRESSURE BLOWING • EXHAUSTING • FORCED DRAFT • INDUCED DRAFT • AIR CLEANING

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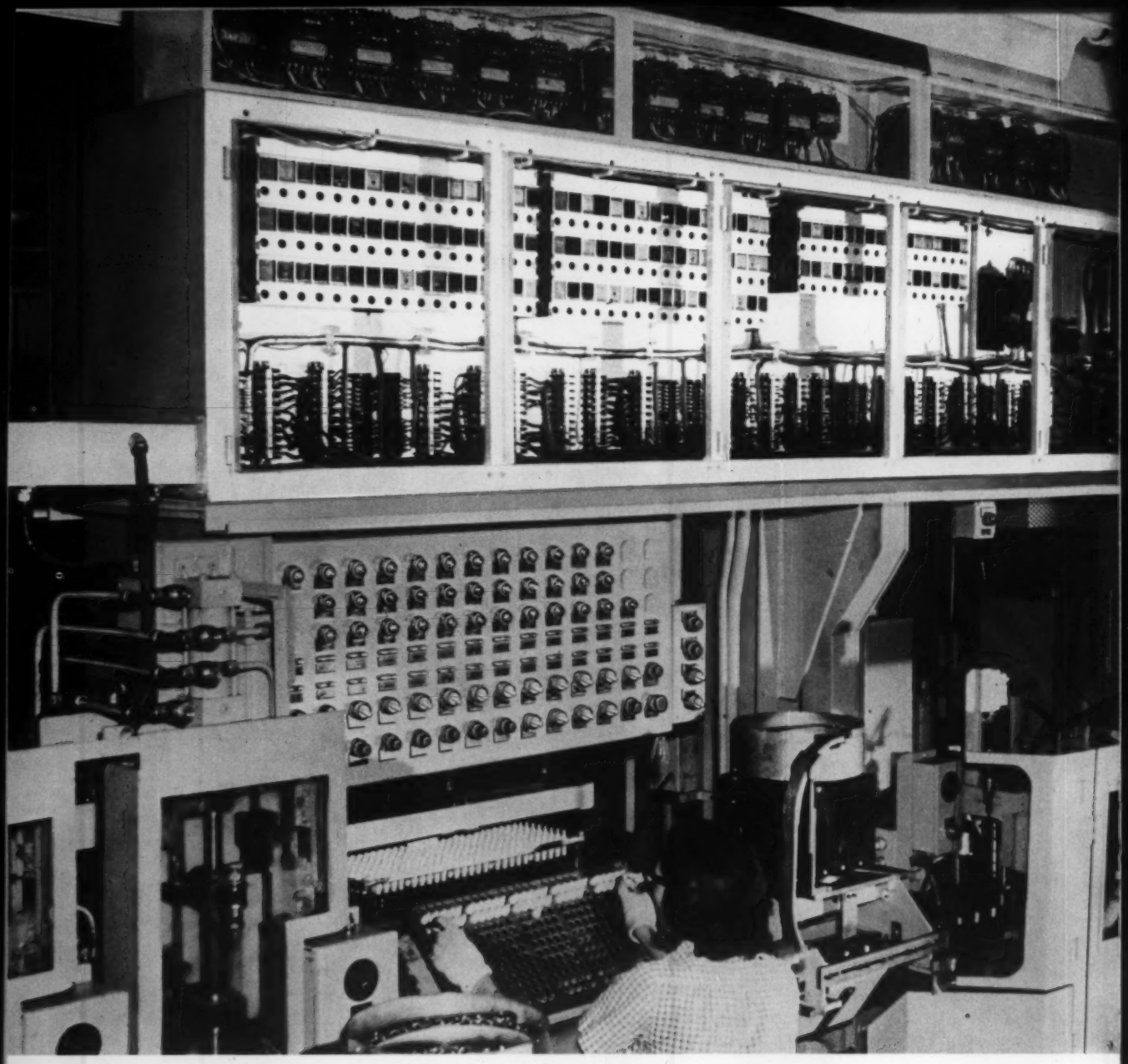
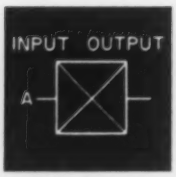
Circle 462 on Page 19→

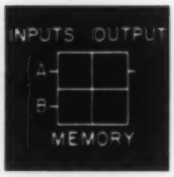


FIVE BASIC CONTROL FUNCTIONS OF G-E STATIC CONTROL "LOGIC ELEMENTS"

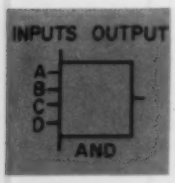
G-E static control "logic elements" correspond to relays in conventional control. They convert a combination of inputs into a single output by controlling the impedance of an output coil. Any static control panel* consists of proper combination and sequencing of these five basic logic control elements:



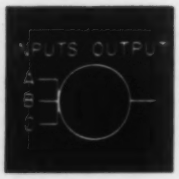
THE "NOT" ELEMENT produces an output only when input A is *not* present. Conversely, when input A *is* present, the "not" element will *not* produce an output.



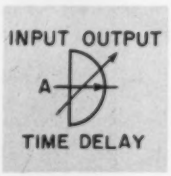
"MEMORY ELEMENT" maintains its output after momentary A input, *until* a momentary B input stops the output. Another A input is necessary to renew the output.



THE "AND" ELEMENT will deliver an output *only* when all inputs (A, B, C, and D) are present. Three inputs or less *cannot* cause the element to deliver an output.



THE "OR" ELEMENT will produce an output when input A *or* B *or* C *or any* combination of inputs is present. One, two or three inputs will produce an output.



THE "TIME DELAY" ELEMENT will produce an output *after* a pre-set time period following an A input. Output then continues until input A is removed from circuit.

*The *complete* static control system includes power supply, amplifiers, logic elements, and panel mounting components.

General Electric's Proved...

Static Control Components Reduce Machine Downtime

PLUG-IN COMPONENTS WITHOUT MOVING PARTS GIVE REAL DESIGN FLEXIBILITY, SPEED ASSEMBLY

Static control is now a *proved* method of control that's easy to adapt to your machines. It's ideal wherever long, dependable operation is vital, and where shutdowns cannot be tolerated, because static control life is *independent of the number of operations.*

G-E static control components simplify panel design

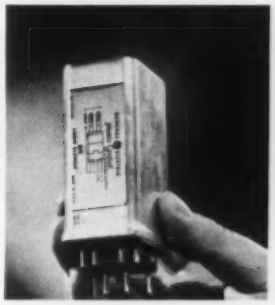
Five basic General Electric logic functions can be combined to perform your control operations. All *you* have to do is translate the operation of your machine into logic functions — then combine G-E logic elements into the proper sequence.

Panel assembly is fast and easy

General Electric logic elements are only 4¼" high, weigh less than 5 ounces. Parts are encapsulated in a resilient compound and encased in aluminum. Each element is color-coded as to function, and plugs into a base receptacle which is connected to a printed circuit. You need do only a minimum of wiring.

A typical user reports

A major automotive manufacturer expects the static control panel with G-E components on the spark plug assembly machine shown at left to significantly increase production because of reduced downtime. The electrical supervisor of the manufacturing development section says: "Our first static control panel was on a different high-speed assembly machine — where maintenance could be a real problem. With Static Control, we haven't had an electrical control failure of any kind in a year. We now have three panels in use, and are designing panels for others where maintenance of conventional control has posed a problem. We chose G-E components because of the simplicity of the system, easier wiring, and their practically fail-safe operation."

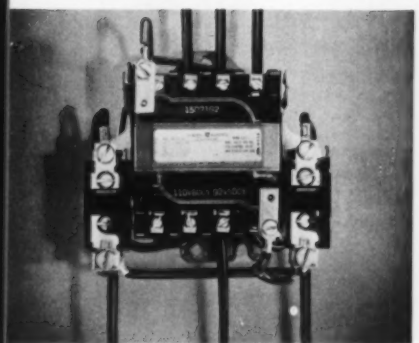


Static Control Logic Element

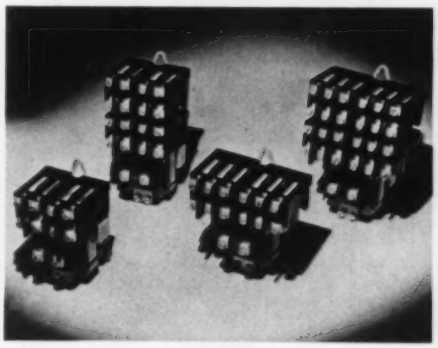
Static Control is available today in simple, easy-to-use components that are proved in service. If you haven't yet investigated G-E static control components, why not do so right now? Just call your G-E Apparatus Sales Office, or write Sect. 731-14, Schenectady, N. Y., for bulletin GEA-6578.

General-Purpose Control Dept., Bloomington, Ill.

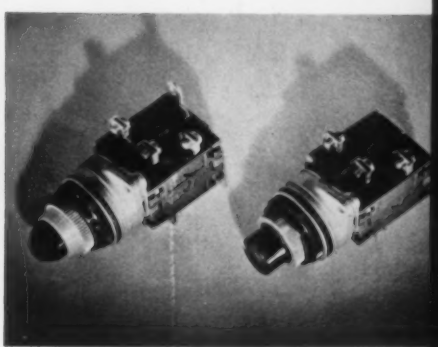
GENERAL ELECTRIC



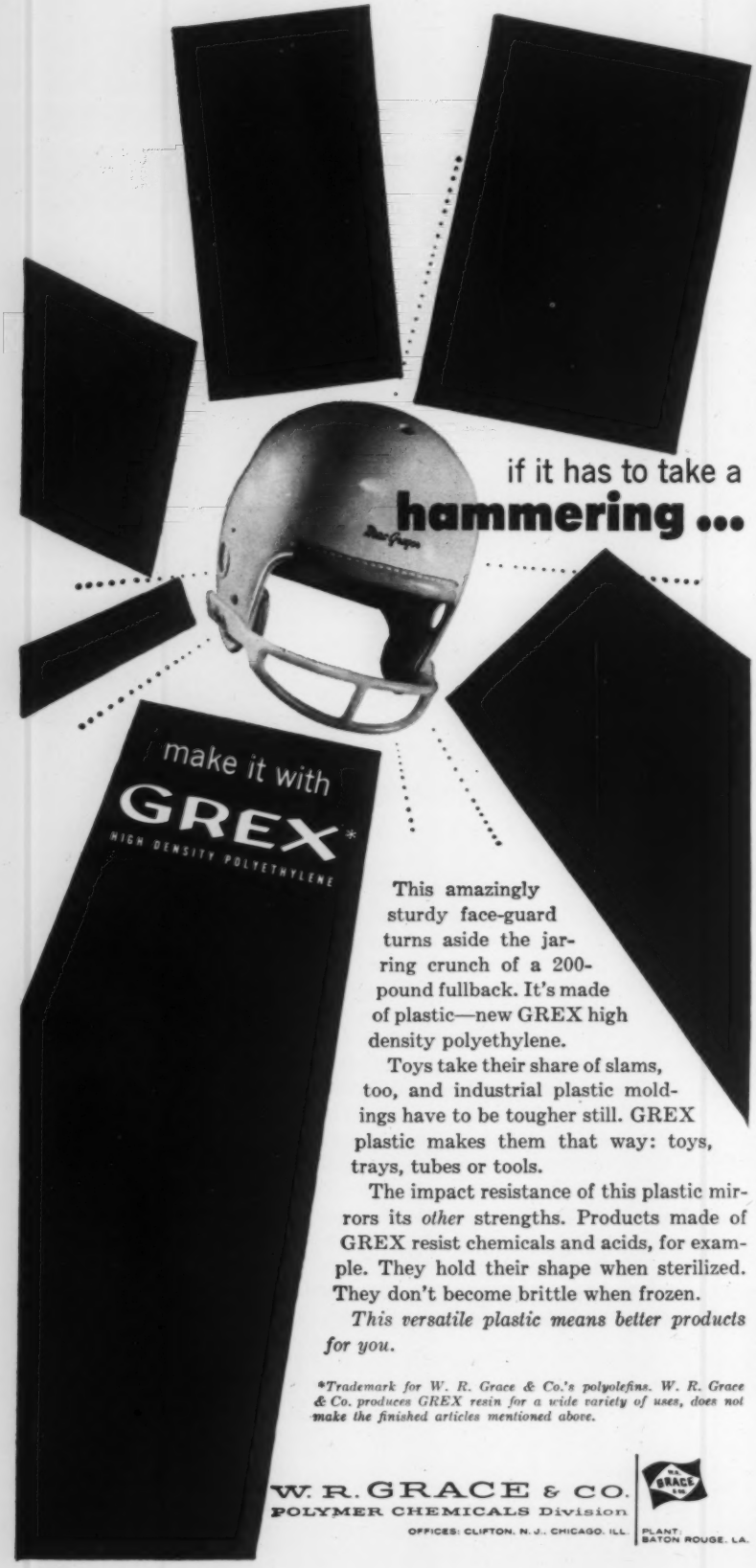
NEW 100-LINE MAGNETIC STARTERS, Sizes 0 and 1, are 42% smaller. They save valuable panel space, use 47% smaller control transformers, and they feature straight-through wiring.



MACHINE TOOL RELAYS have front-connected terminals and are easy-to-wire from four directions. They're available with 2 through 12-poles, and in both standard and latched-in forms. Ratings: 110 to 600 volts, 60 cycles.



PUSH BUTTON UNITS: The G-E push to test unit provides a fast, easy check for burned-out bulb and the new G-E illuminated push button unit reduces panel space by 50%.



GREX* in action

This amazingly sturdy face-guard turns aside the jarring crunch of a 200-pound fullback. It's made of plastic—new GREX high density polyethylene.

Toys take their share of slams, too, and industrial plastic moldings have to be tougher still. GREX plastic makes them that way: toys, trays, tubes or tools.

The impact resistance of this plastic mirrors its *other* strengths. Products made of GREX resist chemicals and acids, for example. They hold their shape when sterilized. They don't become brittle when frozen.

This versatile plastic means better products for you.

**Trademark for W. R. Grace & Co.'s polyolefins. W. R. Grace & Co. produces GREX resin for a wide variety of uses, does not make the finished articles mentioned above.*

W. R. GRACE & CO.
POLYMER CHEMICALS Division
OFFICES: CLIFTON, N. J., CHICAGO, ILL.
PLANT: BATON ROUGE, LA.

Introduction to the Laboratory

Gleaming, chrome-faced cannonballs thud against a newly-molded plastic container. Objects whirl in the ultraviolet light of a test chamber. An endless strip of sandpaper rubs at the surface of a gear.

Here, in the laboratories of W. R. Grace's Polymer Chemicals Division, at Clifton, N. J., we pre-prove our product, GREX, for our customers.

Condensing the Calendar

In three weeks we can duplicate three years' exposure to sunlight, rain and freezing temperatures. A year's wear on a utensil is condensed into a week.

On the production floor, injection molding machines hum as we measure temperatures and pressures needed for GREX-molded radio housings. Sheet and film roll from extruders and are tested for uniformity and gloss. Nearby are facilities for compression molding, vacuum forming, blow molding, heat sealing and paper coating.

Reports for Customers

This unusual laboratory—actually a plant—creates nothing commercial, makes nothing for actual sale. Reports on its labors are given freely to GREX customers and prospective users.

These modern, complete facilities were built for the convenience of Polymer Chemicals customers. They function on your behalf—and can begin working on your problem immediately.

Simultaneously our Marketing Department can cooperate in helping you determine potentials and marketing methods, drawing upon the wide, varied experience of its personnel.

To learn more about GREX and the service it offers, *write today.*

W. R. GRACE & CO.
POLYMER CHEMICALS DIVISION
Dept. 4A-225 Allwood Rd., Clifton, N.J.
Please send further information about GREX for the following applications:

_____

_____

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____

STATE_____

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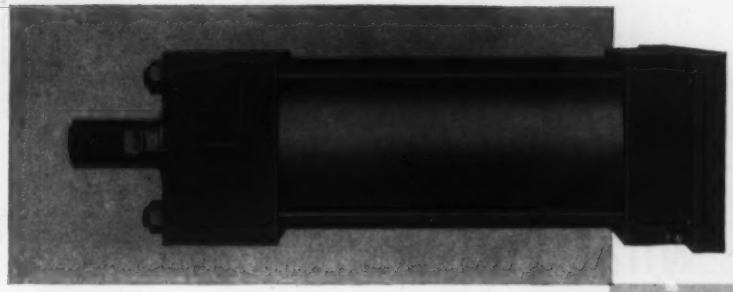
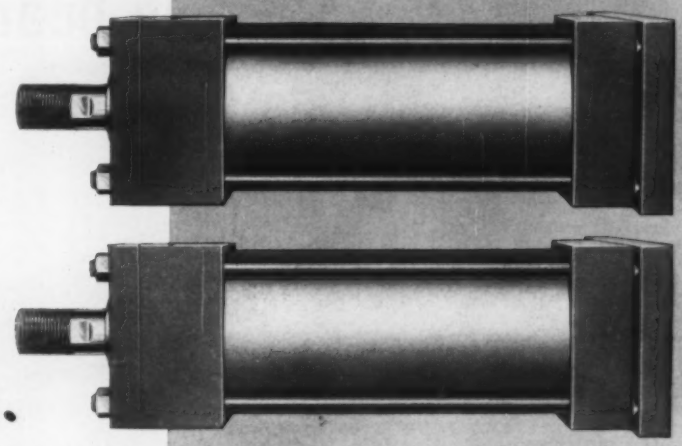


SHOWN HERE:
A Logansquare cylinder and
2 competitors' cylinders

do they LOOK ALIKE? ...sure they do on the surface...



Logansquare Cylinders

are made to interchange with other leading manufacturers' cylinders . . .

...BUT LOOK AT Logan's BIG EXTRA PLUS VALUES

1. Logan designs assure the service required for those extra-rugged applications.
2. Over FORTY YEARS of cylinder manufacturing know-how.
3. Built by CRAFTSMEN whose average service record with LOGAN is more than 20 years.
4. Manufactured in a plant which applies the most modern production methods.

FREE

SEND FOR THE "LOGAN CALCULATOR"

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-6 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 AND 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

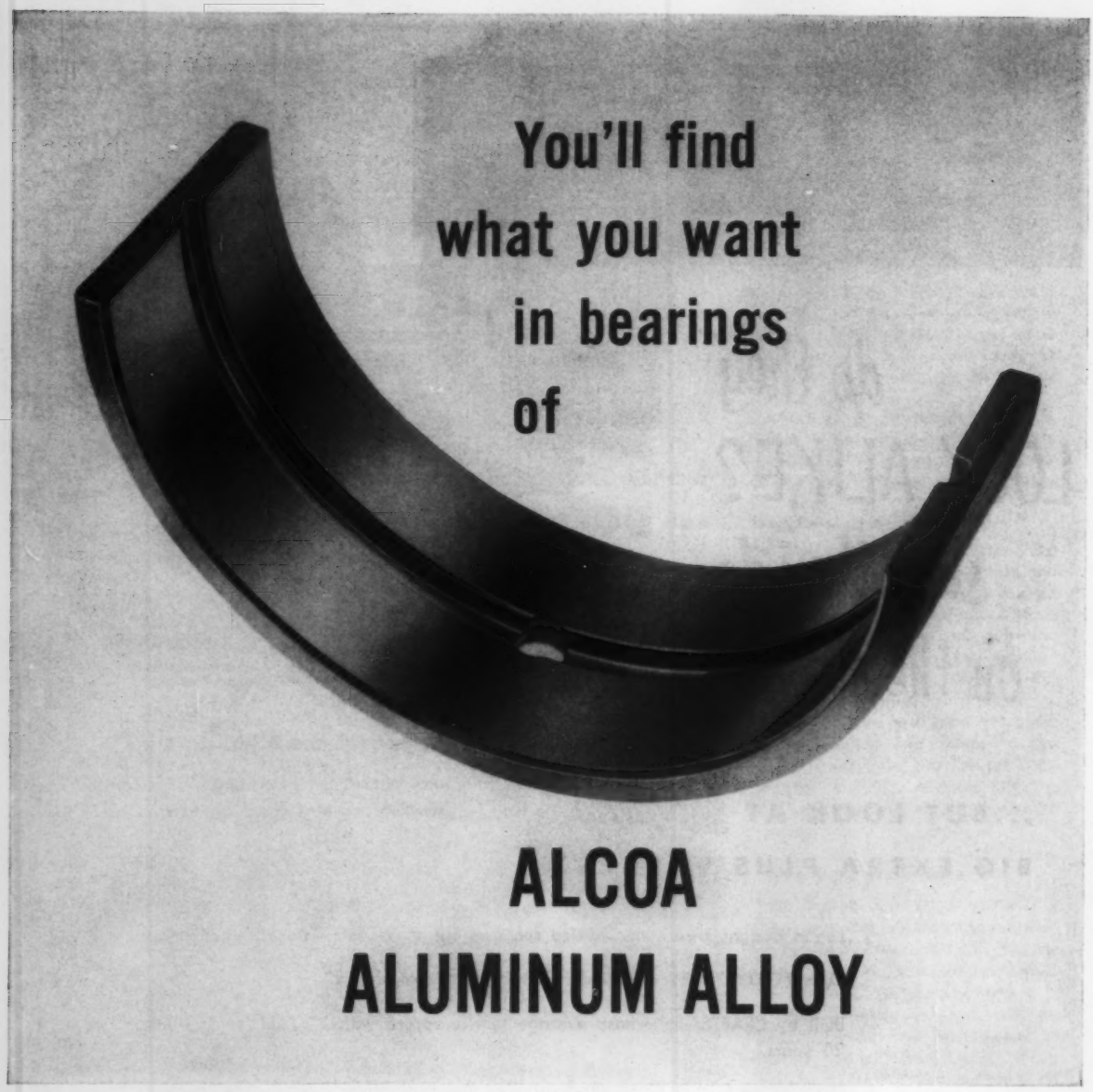
TO:

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

Circle 464 on Page 19



Ability to carry heavy loads . . . up to 10,000 psi on projected area.

Cooler Running . . . Aluminum is the best heat conductor among bearing materials, thus runs cooler . . . as much as 20° by actual test.

Good Conformability . . . Aluminum has good ductility, conforms readily to misalignment of shafts or nonparallel pins.

Ideal Embeddability . . . Aluminum embeds particles better than bronze, not as deeply as babbitt; dirt particles roll out easily and are trapped by filter.

Corrosion Resistance . . . Aluminum resists corrosion, is unaffected by additives in oils, needs no protective coating.

Design Flexibility . . . Aluminum has it; structural properties allow for greater flexibility in design . . . ease of machinability, too!

For more information on the unmatched combination of advantages in solid aluminum alloy bearings, call your nearest Alcoa sales office. Or, write to Aluminum Company of America, 1986-C Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM BEARINGS

Your Guide to the Best in Aluminum Value

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

Circle 465 on Page 19

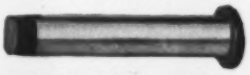
"Full-round" design of Link-Belt LXS chain avoids stress raisers

ROLLERS are accurately machined for correct operating clearances and free-rolling action.

SIDEBARS of selected steel have accurately machined "full-round" pitch holes, which maintain firm, tight press fit of pins and bushings.

FOR POWER TRANSMISSION, LXS chain is generally supplied with offset sidebars. Uniform stress distribution provides extra chain life and safe dependable operation.

FOR CONVEYING AND ELEVATING, LXS chain with straight sidebars and rollers to meet varied operating conditions. A wide variety of attachments is available.



"FULL-ROUND" PINS are made from a tough steel, specially treated for high strength in shear . . . sized for controlled press fit to prevent rotation in sidebars.

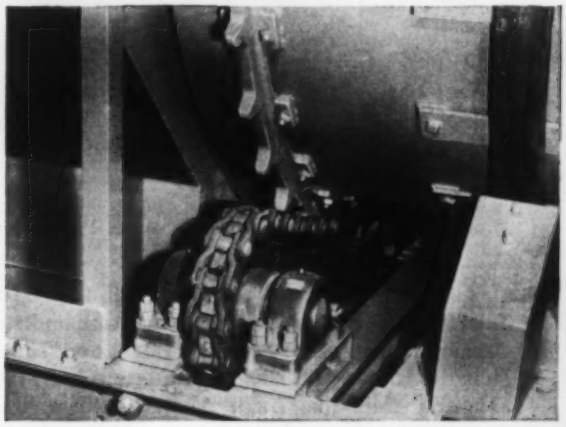
"FULL-ROUND" BUSHINGS are properly hardened to shrug off shock, resist wear . . . accurately sized for controlled press fit to prevent rotation in sidebars.

Greater live bearing area extends life

Stress concentration points are eliminated in Link-Belt LXS chain! "Full-round" design avoids sharp corners which may be the starting points of chain failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly . . . long chain life is assured under severe conditions.

Pins and bushings of LXS chain are accurately sized . . . assuring controlled press fits, preventing rotation in sidebars. Similar accuracy in machining of sidebars permits close control of pitch and proper chain length after assembly.

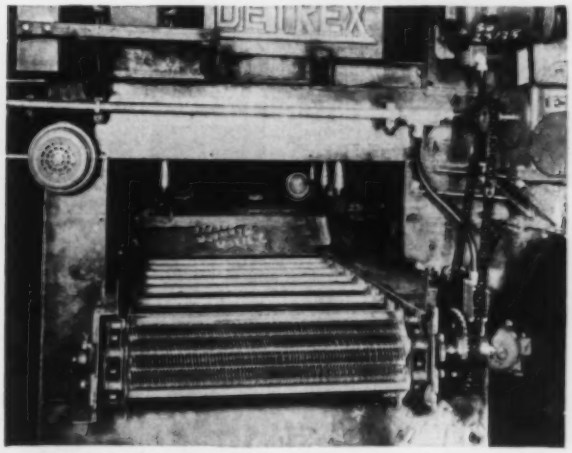
Other long-life features of Link-Belt LXS chain include use of selected steels and controlled hardening of all parts. Both contribute to greater endurance . . . greater uniformity.



LXS drives stand up to impact and abrasive service

Large, live bearing area makes LXS chain ideal for exposed drives and abrasive conditions such as found on this heavy rotating drum. Uniform distribution of load over ample bearing area reduces cutting action of abrasives . . . extends chain life.

LXS chain has stamina required for long, heavy-duty conveyors



With its exceptional strength and wear resistance, Link-Belt LXS chain can easily meet rugged conveying and elevating requirements. Due to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life necessary for the extra-long conveyors so important to today's highly mechanized industry.

HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt office.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,741

NEW TESTS HIGHLIGHT ASSETS OF LEATHER PACKINGS

- **Flesh Side Out — lower friction regardless of impregnation**
- **Flesh Side Out — lower porosity regardless of impregnation**
- **Rubber Impregnation — lower friction than hard wax**
- **Rubber Impregnation — less leakage than hard wax**
- **Uniquely Designed Houghton 1243-3 Cups — superior to all other types**

DESIGNERS AND MAINTENANCE MEN both are interested in modern leather packings. Their resistance to abrasion and extrusion, their compatibility with modern fire-resistant hydraulic fluids, and their strength under high operating pressures spell long, trouble-free service and makes them ideal seals under many combinations of process conditions.

In response to the demand for further technical data on friction and porosity benefits from leather packings, Houghton engineers recently completed a comprehensive study of the conventional leather cup packings used in industry today. The findings are headlined above.

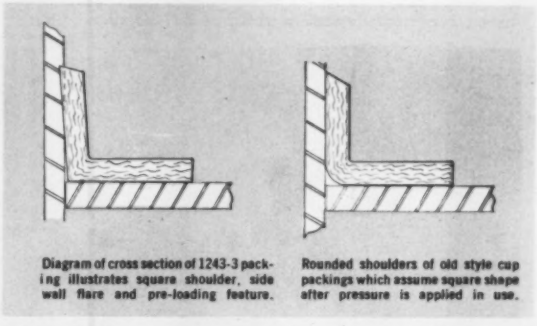


Diagram of cross section of 1243-3 packing illustrates square shoulder, side wall flare and pre-loading feature.

Rounded shoulders of old style cup packings which assume square shape after pressure is applied in use.

TEST RESULTS

Synthetic Rubber—(Houghton 1243-3) flesh out, flared wall, square shoulder

No. of Cycles	Friction Push	Friction Pull	Test Pressure	Pressure Increased To	Oil Loss Milliliters	Strokes Per Minute	Average Cylinder Temp.
500	20 lbs	0 lbs	500 psi			30	80°F
	25 lbs	0 lbs		1,000 psi		15	
700	25 lbs	10 lbs	1,000 psi			30	82°F
	25 lbs	10 lbs		2,000 psi		15	
900	40 lbs	10 lbs	2,000 psi		no measurable loss	30	83°F
	40 lbs	10 lbs		3,000 psi		15	
1,100	60 lbs	25 lbs	3,000 psi			30	84°F
	60 lbs	25 lbs		4,000 psi		15	
1,300	75 lbs	40 lbs	4,000 psi			30	85°F
	75 lbs	40 lbs				15	

Wax—Grain out, straight wall, round shoulder

No. of Cycles	Friction Push	Friction Pull	Test Pressure	Pressure Increased To	Oil Loss Milliliters	Strokes Per Minute	Average Cylinder Temp.
500	125 lbs	175 lbs	500 psi		32	30	80°F
	150 lbs	225 lbs		1,000 psi		15	
700	150 lbs	225 lbs	1,000 psi		38	30	100°F
	175 lbs	250 lbs		2,000 psi		15	
900	175 lbs	250 lbs	2,000 psi		40	30	105°F
	200 lbs	300 lbs		3,000 psi		15	
1,100	200 lbs	250 lbs	3,000 psi		41	30	110°F
	275 lbs	325 lbs		4,000 psi		15	
1,300	250 lbs	275 lbs	4,000 psi		42	30	115°F
	275 lbs	325 lbs				15	

THE PACKINGS TESTED... included both wax and rubber impregnated types with round and square shoulder, flared and straight wall, and with flesh side and grain (hair) side of the leather as the contacting surface. In order to achieve equality in test conditions, all cups were identically spring-loaded when mounted.

JUSTICE MACHINE TESTING... The cups were driven for various numbers of cycles under different oil pressures in our Justice machine. In such tests highly accurate measurements of surface finish and power loss due to friction are made. A comparison of typical test results is shown at the left. Complete results are available on request.

FLESH-OUT THEORY... The porosity results substantiated a long-standing theory on the superior performance of leather packings moulded with the

flesh side out. According to this theory, moulding the flesh side out minimizes leakage because the tightly knitted grain surface is next to the pressure and does not wear away in service.

TOP PERFORMANCE OF 1243-3 CUP... The tests also reaffirmed the superior performance characteristics of Houghton's 1243-3 leather cup impregnated with synthetic rubber. The unique impregnation developed by Houghton researchers is much more than a surface coating. The liquid rubber polymer is actually channeled down among the fibers of the leather for a complete permanent impregnation which imparts the sealing qualities and pliability of rubber to the strong wear-resistant leather packings.

Houghton's unique synthetic rubber impregnation gives this 1243-3 leather cup the pliability and sealability of rubber.

ENGINEERING NEVER STOPS. The recommendations of a Houghton packing engineer are always based on facts obtained through tests like this leather packing study. Houghton developments include standard stack heights for "V" packings (making possible the interchangeability of packings of various materials without redesign of the gland). The pre-forming of square shoulders, and the spring mounting technique described above are Houghton developments. Houghton engineering has contributed to better packing materials, simplification of hydraulic systems engineering, more efficient hydraulic fluids.

When you specify Houghton packings you'll find on-time delivery and prompt service as much a part of our program as sound engineering. Check the full line at the right. Pick the packings you need and contact the Houghton Man or write for engineering data. Specific folders on each type are available. Write E. F. Houghton & Company, 303 West Lehigh Ave., Philadelphia 33, Pennsylvania.

HOUGHTON PACKINGS FOR HYDRAULIC AND PNEUMATIC SYSTEMS

"VIM" LEATHER PACKINGS

Over 140 combinations of leathers and impregnations have been developed by Houghton's research department, to fit nearly all conditions. They provide efficient seals against oil, brine, water, oxygen, phosphate esters and other mediums.

Cups, flange, "U", "V"—flat washers, discs and gaskets—for oil, air, water or gas applications—engineered for smoother, more positive sealing action at all pressures and temperatures up to 160°F.

"VIM" No. 1243-3 RUBBER-IMPREGNATED LEATHER PACKINGS

Our most recent packing development is the complete impregnation of leather packings with synthetic rubber. Thorough impregnation combines the durable strength of leather with the non-porosity and resilience of rubber—easy to install, excellent sealing and less friction at low and high pressures.

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Our special moulding process results in a more compact structure, and more uniform density. Line includes homogeneous and fabricated packings, gaskets, O-rings—and "Vim" leather back-up washers designed for use with Vix-Syn O-rings.

GET THESE HANDBOOKS DESCRIBING HOUGHTON PACKINGS AND ENGINEERING SERVICE

1. "Handbook on Leather Packings" includes complete data on hydraulic and pneumatic applications.
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A COMPLETE FAMILY OF FLUIDS, TOO

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Houghton's high quality hydraulic oil is fortified for maximum efficiency.

"HOUGHTO-SAFE" FIRE-RESISTANT HYDRAULIC FLUIDS

Water-base and Phosphate Ester types.

HYDROLUBRIC F.R.

Emulsion type fluid.

"HYDROLUBRIC" ADDITIVE FOR WATER

For closed water hydraulic systems.

PACKINGS

...products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service...

Circle 467 on Page 19

FAST, HAMMER-DRIVEN RIVET ECONOMICAL FOR BLIND AND OPEN APPLICATIONS

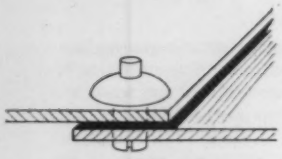


Fig. 1 Inserted in hole, Southco Rivets are quickly set by driving pin with hammer. No special tools are required. Bucking is not necessary.

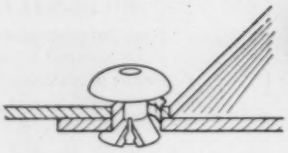


Fig. 2 Expanded prongs force sheets or parts together, hold them tightly in compression. No metal is removed, no grinding or finishing is required.

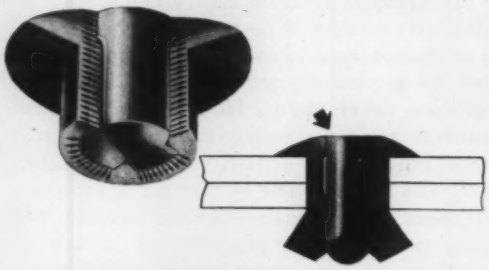


Fig. 3 Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

Fig. 4 Ideally suited for "blind" applications, Southco Rivets are worked by one man from one side only and require minimum space inside closed area. They eliminate costly bucking arrangement or time-consuming finishing. Supplied as a unit, they require no job time for assembly or fitting.

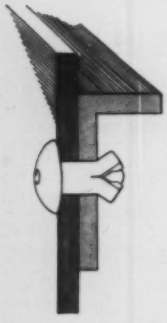


Fig. 5 Access or open fastening utilizes the simplicity, speed and vibration-resistance of Southco Rivets.

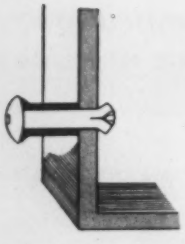


Fig. 6 Ferrules are used as spacers for numerous applications. Here the Southco Rivet forms a drawer pull in conjunction with a flanged tube.

Fig. 7 Increased head size distributes holding pressure over larger area, permits higher loading on wood, plastics and similar materials.

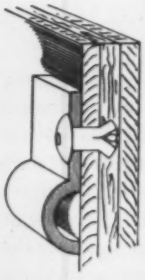
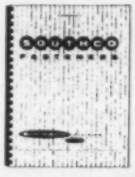


Fig. 8 A blind head can be formed inside the wood. This application is particularly useful when it is desirable to have one surface of the wood unmarred.

FREE!
Fastener Handbook



Send for your free copy of Handbook No. 7. Complete data for designers on these and many other specialty fasteners. 52 pp., two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

SOUTHCO FASTENERS
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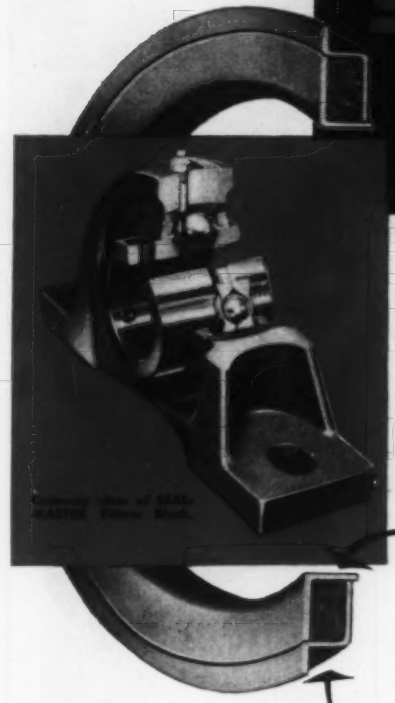
LION

SEALMASTER'S *Patented*

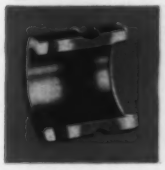
LABYRINTH SEAL

PREVENTS ENTRY OF DUST AND DIRT AND RETAINS PROPER AMOUNT OF LUBRICANT FOR LONG BEARING LIFE!



Ability of SEALMASTER Ball Bearing Units to perform smoothly amid conditions of dust, dirt and grime, is largely due to the design of the Sealmaster patented Labyrinth Seal. Consisting of felt-lined steel flingers rotating in labyrinth, the SEALMASTER Seal prevents entry of dirt and dust into the bearing unit and retains the lubricant within the ball path area. A feature you will want in the bearing units you specify. Remember — there is only one SEALMASTER Seal — most copied because it's most effective.

PLUS THIS EXCLUSIVE COMBINATION OF FEATURES!



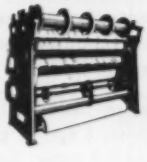
ZONE HARDENING . . . assures positive race to shaft holding power. Reduces corrosion.

LAND RIDDEN BALL RETAINER . . . minimizes ball wear, traps grease and prevents "churning."

LOCKING PIN & PERIMETER DIMPLE . . . prevents rotation of outer race, assures positive lubrication.

KEEP 'EM ROLLING WITH SMOOTH PERFORMANCE AT EVERY TURN!

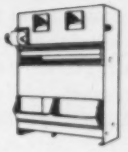
MACHINE TOOLS
SEALMASTER quality pays off where the trend is to continuous, fast, automatic equipment.



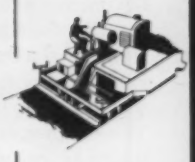
TEXTILE INDUSTRY
Clean, fast production is assured with SEALMASTER Bearings.

FARM MACHINERY
SEALMASTER Ball Bearing Units keep dust and dirt out, lubricant in—a feature Farm Machinery demands.

CONVEYORS
SEALMASTER Ball Bearing Units are featured by manufacturers of many types of conveyors.



AIR CONDITIONING
Quiet, trouble-free performance is assured with SEALMASTER. Find out about new rubber mounted units.



CONSTRUCTION MACHINERY
SEALMASTER Ball Bearing Units provide the features for gruelling performance in construction and materials handling equipment.

SEALMASTER®
BALL BEARING UNITS

Write for Bulletin 454

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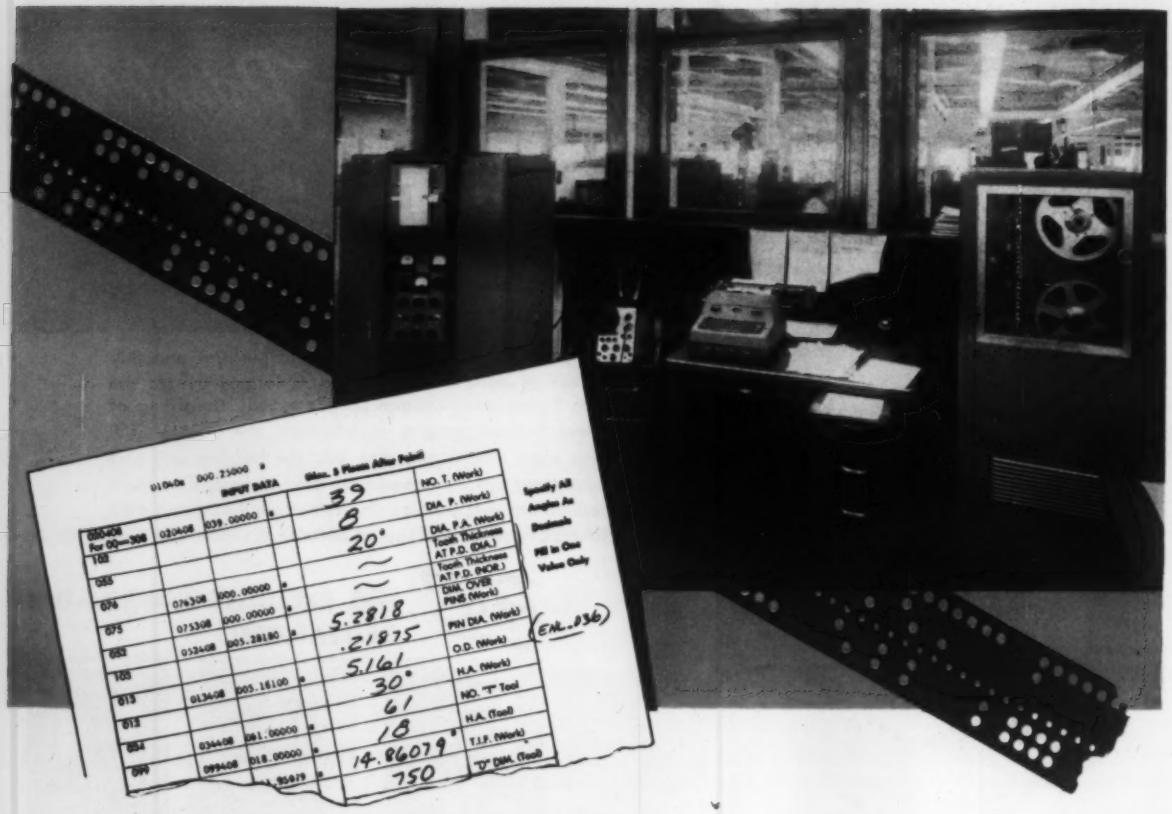

COMPUTER TECHNIQUES

solve special gear and cutter designs

Giving designers exceptional freedom in their specifications for special gears to improve design, the electronic computer easily makes the calculations necessary for making cutting tools to meet the most critical requirements. This high-speed Bendix Computer shortens hours of calculation to minutes, permitting complete mathematical study of complex problems.

A punched tape holds the basic formulae, the computer program. Variables for a particular Fellows Cutter, Shaving Tool, or Master Gear are typed on an electric typewriter which feeds them into the computer. As fast as the operator can type, the computer does the figuring which used to require hours of labor.

Fellows Gear Shapers tooled with Fellows Cutters lower costs and speed production on internal and external spur, helical and herringbone gears. Many examples of interest to designers are shown in the booklet, "The Art of Generating with a Reciprocating Tool." Just write any Fellows office for your copy.

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HALOID XEROX®

Circle 471 on Page 19

Tubexperience in action

Special mill services through your Superior Tube distributor

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Requirements like these call for a tubing specialist.

CONTACT A SUPERIOR TUBE DISTRIBUTOR

His broad experience can help you solve many problems. But most important of all—he can acquaint you in detail with many special services offered by the mill. These include statistical quality control, nondestructive tubing inspection and testing, pilot and test lot sampling and melting, field specialist and specification services—there are many more.

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For more information about Superior tubing, write for a free copy of Bulletin 40, "A Guide to the Selection and Application of Superior Tubing." Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

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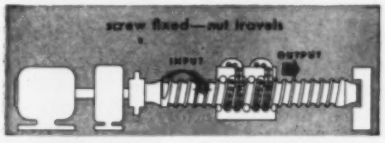
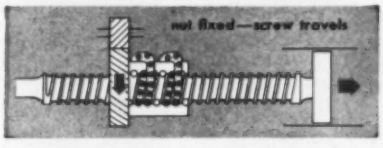
BALL CIRCLE DIAMETER: 3/16 inch.

WORLD'S SMALLEST ball/bearing SCREW SOLVES CRITICAL MINIATURE POSITIONING/CONTROL PROBLEMS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .0005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation. Just phone, write or mail the handy coupon.

Saginaw

ball bearing Screw

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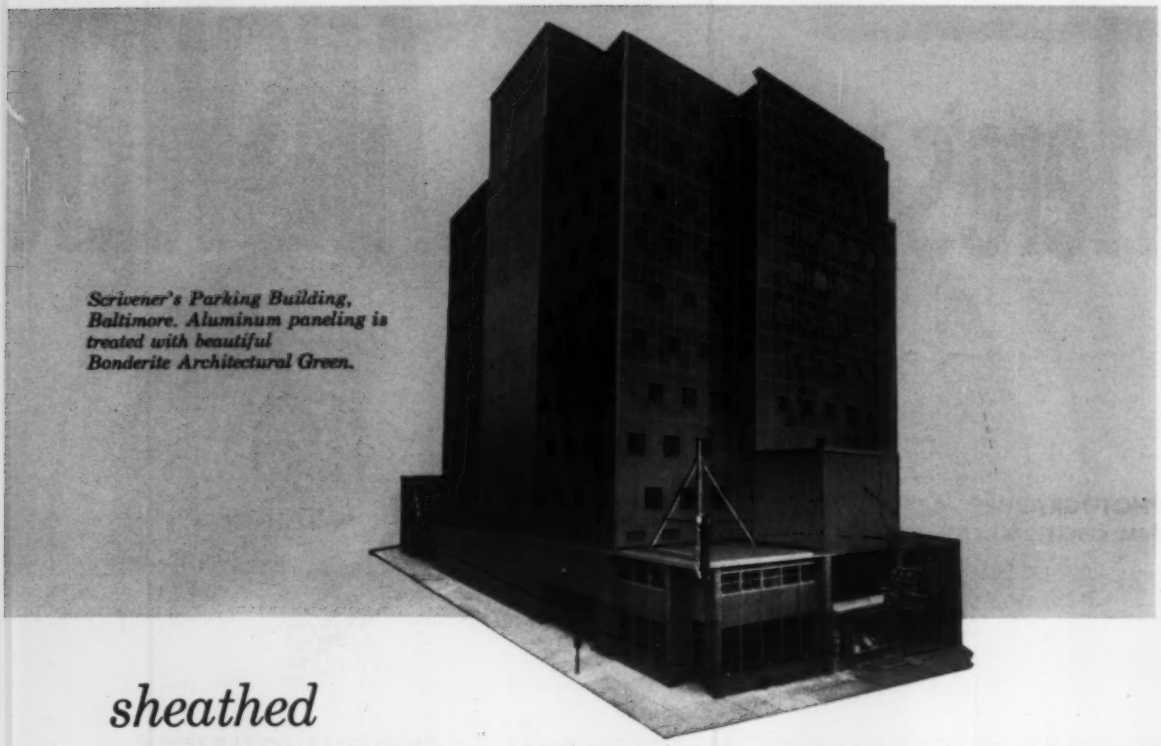

Scrivener's Parking Building, Baltimore. Aluminum paneling is treated with beautiful Bonderite Architectural Green.

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You'll see many more buildings, like this attractive structure in Baltimore, using aluminum finished with Bonderite Architectural Green. There are so many things to recommend this beautiful, durable Bonderite coating!

Treatment with Bonderite Architectural Green protects aluminum from corrosion. The same protective treatment chemically produces a soft, lasting green color which is a part of the integral coating of the metal surface. Color is sun-and-weather-fast.

Bonderite Architectural Green costs far less than electrolytically produced color coatings for aluminum. It is simple to use, and the color uniformity is a sure visual check on the uniform quality of the coating, maintained in volume production day in and day out.

Bonderite Architectural Green may be applied by spray or immersion, and by continuous strip treatment.

Metal treated in this manner can be used not only in construction panels, but also for siding, awnings, venetian blinds and many items on which the excellent color and durability contribute to a better, more salable product.

Write for descriptive illustrated booklet "Bonderite 700 Series". Details on Bonderite Architectural Green, uses, advantages, characteristics.

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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

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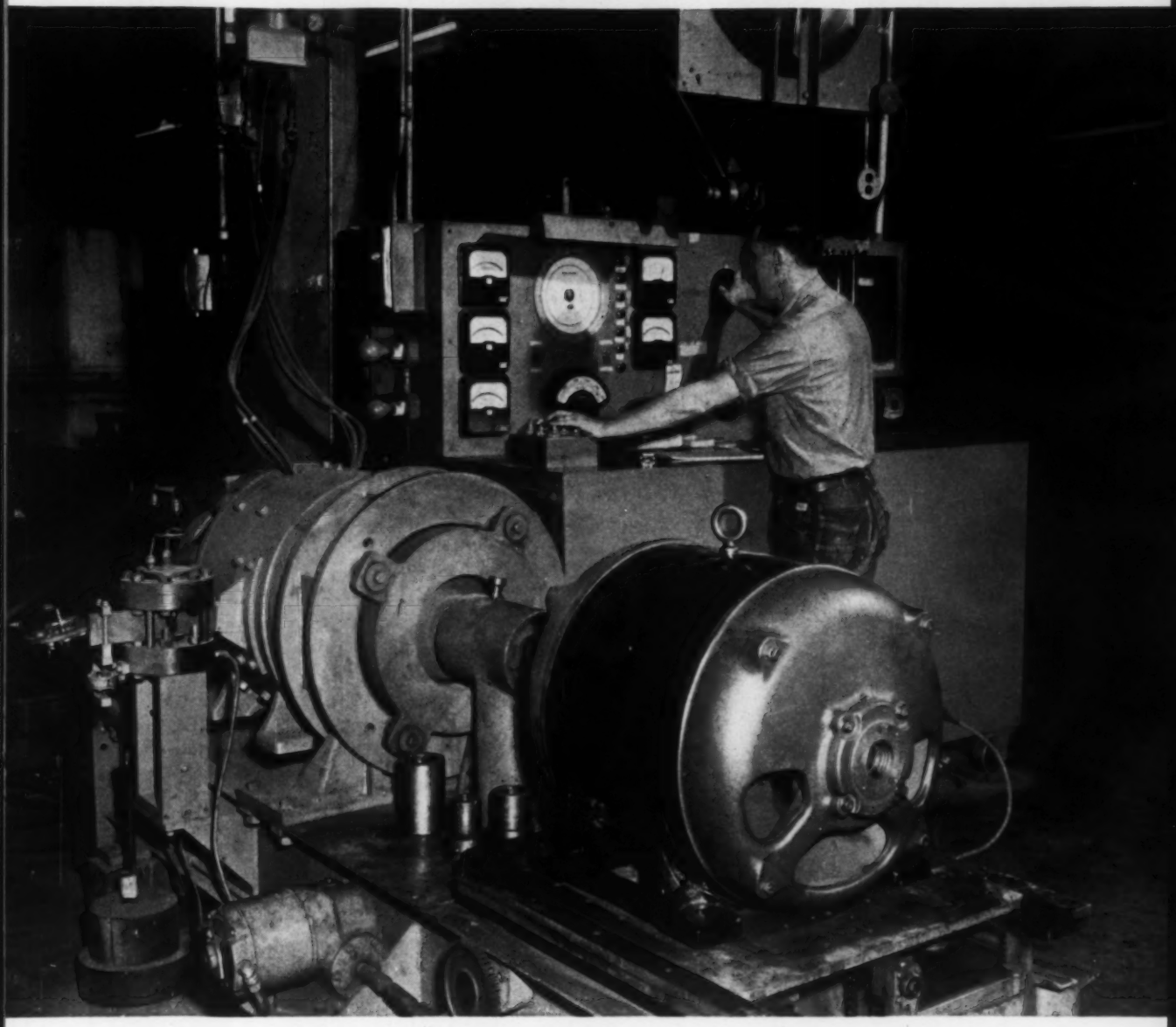

Century tests every motor . . . to make sure it gives full performance

Rigorous performance tests are conducted to prove these electric motors before they get the Century stamp of approval. When you see a Century motor put through its paces you know this approval is well earned.

In this plant there is no "random sampling" or "statistical average" on performance. Century tests every motor . . . big as 400 HP, small as 1/20 HP . . . to make sure you get the performance you expect. Field records—and our customers have furnished us impressive ones—are further proof your best motor investment is Century.

Specify Century's individually tested motors to take care of your requirements. Call your local Century man or Authorized Century Distributor.

Century MOTORS

CENTURY ELECTRIC COMPANY

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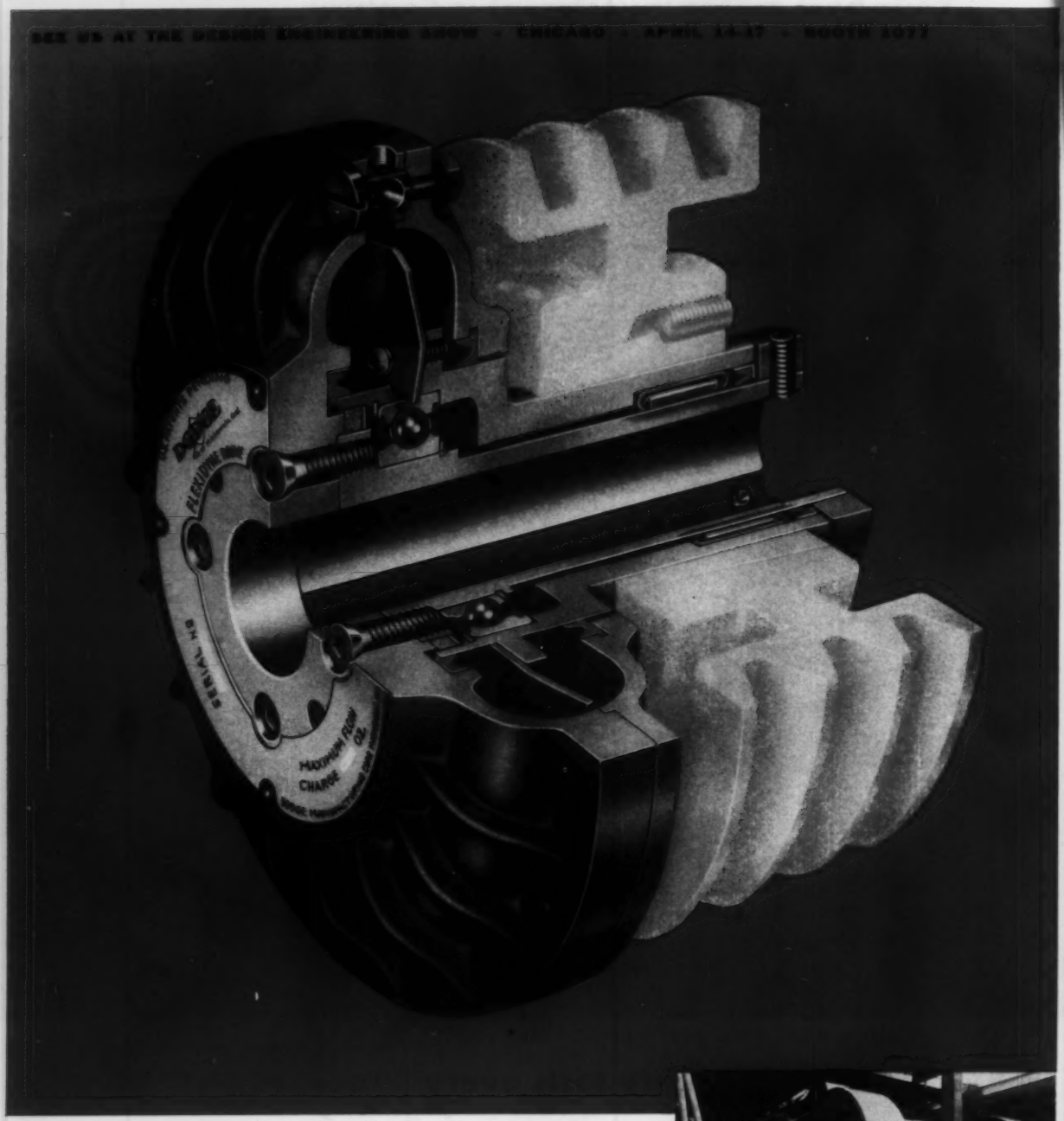
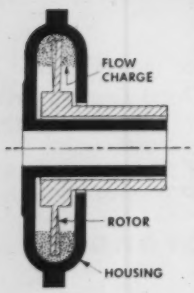
Circle 475 on Page 19

SEE US AT THE DESIGN ENGINEERING SHOW - CHICAGO - APRIL 14-17 - BOOTH 1077

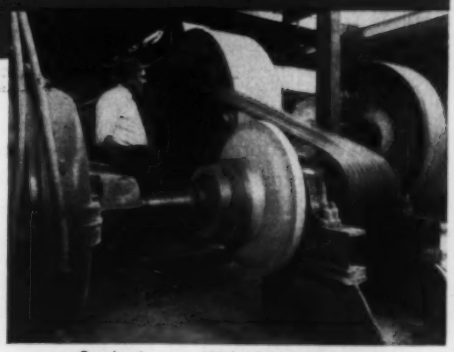




HOW FLEXIDYNE WORKS

The "dry fluid" in Flexidyne is tiny heat-treated steel shot. A measured amount, called the "flow charge," is contained in the housing, which is keyed to the motor shaft. Inside the housing is a rotor, free to revolve relative to the housing, but connected to the load.

When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, packing it between the housing and the rotor, which transmits power to the load. Initial slippage is momentary. Housing and rotor become locked together and achieve full load speed without slip and at 100% efficiency.



Overloads on a 150 hp jaw crusher cause sudden damage. Here Flexidyne is used to minimize this costly trouble. As a bonus, it reduces belt wear and replacement.

FLEXIDYNE

THE DRY FLUID DRIVE

OFFERS A NEW APPROACH TO DIFFICULT DRIVE PROBLEMS...OPENS THE WAY TO MULTIPLE SAVINGS!

IT IS NO LONGER NECESSARY to accept the destructiveness—the costliness — of conventional starting in the mechanical transmission of power! Flexidyne changes that.

LOOK AT YOUR DRIVES! Are you using expensive oversize or high torque motors merely to get your loads started? Are you using expensive starting equipment? Are you tolerating high demand rate? Are your belt maintenance costs high, because of the shock of across-the-line starting?

HOW ABOUT THE MATERIAL YOU PROCESS—wire, paper, textiles? Is your output hampered by breakages that you accept as "normal production"? Do you burn up clutches in getting your loads up to speed?

FLEXIDYNE—THE DRY-FLUID DRIVE—solves these problems—and many more! Flexidyne is revolutionary. *And so simple!* Off the shelf availability. Drives or Couplings. Fractional to 1000 hp. Ask your local Dodge Distributor or write us for technical Bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER —your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

Flexidyne, accurately set for extra gentle starting, solves the problem of thread breakage on this textile beam warper—vastly multiplying productivity.

Smooth starting and deft spotting are required with this 20-ton crane. Flexidyne accomplishes both—and by so doing saved $4,000 in electric controls!

A ball mill drive is a tough one. Flexidyne not only eases heavy starting shocks here but eliminates the necessity *and the cost* of an oversize motor!

Circle 476 on Page 19

For Precision Molded Nylon Gearing

------ *Quinn-Berry* of course!

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Joseph Leader
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Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
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DETROIT 35, Mich.
Harry R. Brethen Co.
16115 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

KNOXVILLE, Tennessee
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7028 Rockingham Drive
Phone: 8-5155

MILWAUKEE 13, Wis.
John Weiland, Jr.
7105 Grand Parkway
Greenfield 6-7161

WYNNEWOOD, Pa.
Austin L. Wright
P. O. Box 12
50 East Wynnewood Road
Midway 2-5113

Unusual applications of precision molded nylon are routine projects at Quinn-Berry . . . gearing for a multitude of appliance, automotive and aviation components. The nylon gear shown above is molded directly onto the shaft to finish dimensions in one operation. Five separate operations were formerly necessary. The result? A 50% cost reduction and improved performance. Nylon gears by Quinn-Berry require no lubrication. They are quiet in operation . . . known to last 20 times longer than gears of other materials in many applications . . . have exceptional ability to withstand vibration.

Quinn-Berry is a pioneer in the precision molding of nylon as well as other thermoplastic materials. For your component parts, put it up to Q-B where the "Unusual is Routine."

WE FLY TO SERVE YOU FASTER!

QUINN-BERRY CORP.
2609 WEST 12TH STREET, ERIE, PA.

MOLDERS OF ALL TYPES OF THERMOPLASTICS

Circle 477 on Page 19

Circle 478 on Page 19→

An improved
Combination Starter
for extra safety

While the changes in the new Allen-Bradley Bulletin 712 and Bulletin 713 starters may be relatively minor, they were made in your interest—to give you the best control on the market.

The new operating lever has been attractively restyled and structurally improved. Now the disconnect switch can be locked "open" or locked "closed"—with three padlocks of any kind. For the maintenance engineer, a concealed latch pin is built into the lever, which permits opening the door of the cabinet without opening the disconnect switch and stopping the motor. The door can also be padlocked shut independently of the operating lever.

With the disconnect lever in the "off" position, the cabinet door can be opened. At a glance, it can be seen that the movable contacts are open. An added "safety" feature—the incoming line connections are covered with an insulating plate to prevent accidental contact.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

BULLETIN 712—These modern A-B combination starters cost no more than a separate starter and disconnect switch, and make a neater, safer, more attractive installation.

Size 1—to 7½ hp, 220 v; 10 hp, 440-550 v.

Size 2—to 15 hp, 220 v; 25 hp, 440-550 v.

Size 3—to 30 hp, 220 v; 50 hp, 440-550 v.

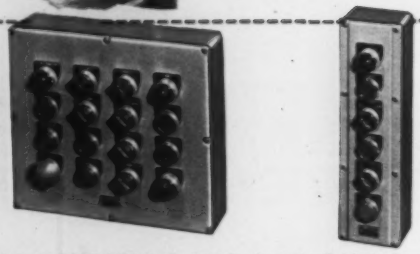
Size 4—to 50 hp, 220 v; 100 hp, 440-550 v.

3-58-MB

Not only the Motor Starters, but the Accessories must be "Quality," too!

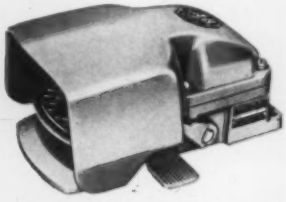
we specify ALLEN-BRADLEY ...all the way

"Trouble" that shows up in a motor starter is often traced to a faulty operating auxiliary—such as a limit switch or even a push button station. Allen-Bradley builds the same high quality into its many accessories as it does into its motor starters—to give you millions of trouble free operations. They are also tested as thoroughly. Contacts are usually double break and always are of a silver alloy, which means they remain in perfect operating condition. It will pay you, too, to specify Allen-Bradley *Quality* control—"all the way!"

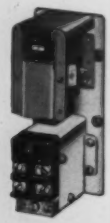


Bulletin 800T Oiltight Control Stations. Available in from one to sixteen units, in die cast aluminum enclosures.

Bulletin 802 Precision Limit Switch, with oiltight head and body.

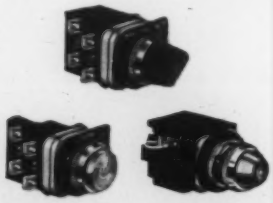


Bulletin 805 Foot Switch. In rugged die cast enclosure for the toughest service.



Bulletin 849 Pneumatic Timer. Reliable and accurate.

Bulletin 837 Temperature Control with snap action, precision switch.



Bulletin 800T Oiltight Push Button, Selector Switch, and Press-to-Test Pilot Light.

Bulletin 800 Standard Duty Push Button. One, two, and three buttons; also as selector switch.

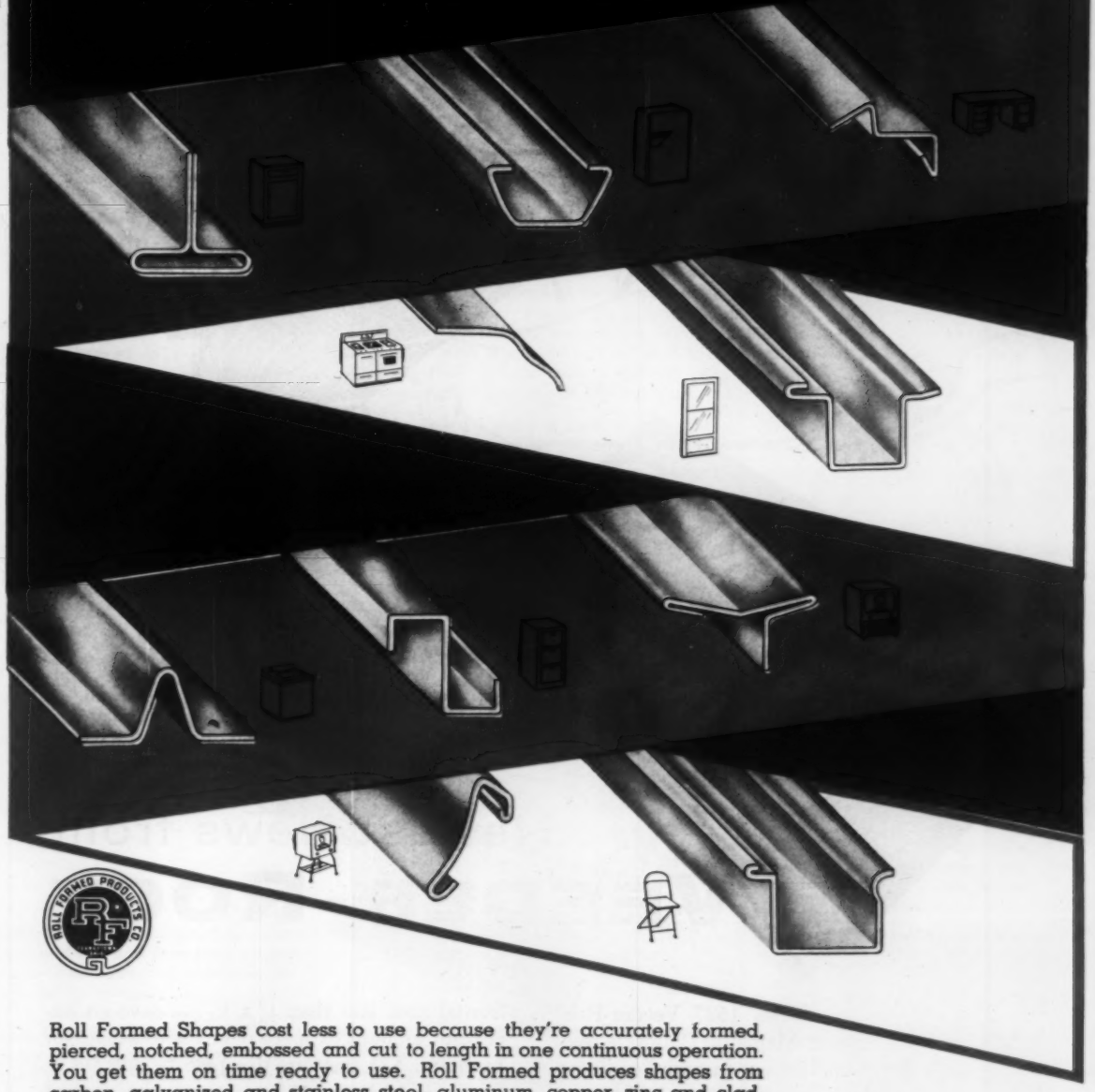
Bulletin 836 Pressure Control in NEMA 4 watertight enclosure.

3-58-MR

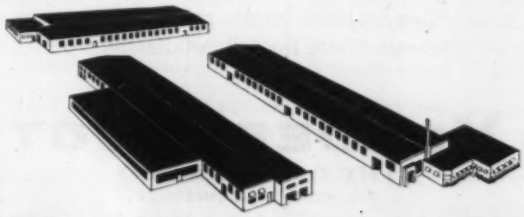
Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

More economy for you . . .



Roll Formed Shapes cost less to use because they're accurately formed, pierced, notched, embossed and cut to length in one continuous operation. You get them on time ready to use. Roll Formed produces shapes from carbon, galvanized and stainless steel, aluminum, copper, zinc and clad-metals. For a fast, thorough analysis of how Roll Formed can help you cut assembly costs, send your prints today. Ask for catalog No. 1555.



ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT 3754 OAKWOOD AVE. • YOUNGSTOWN, OHIO

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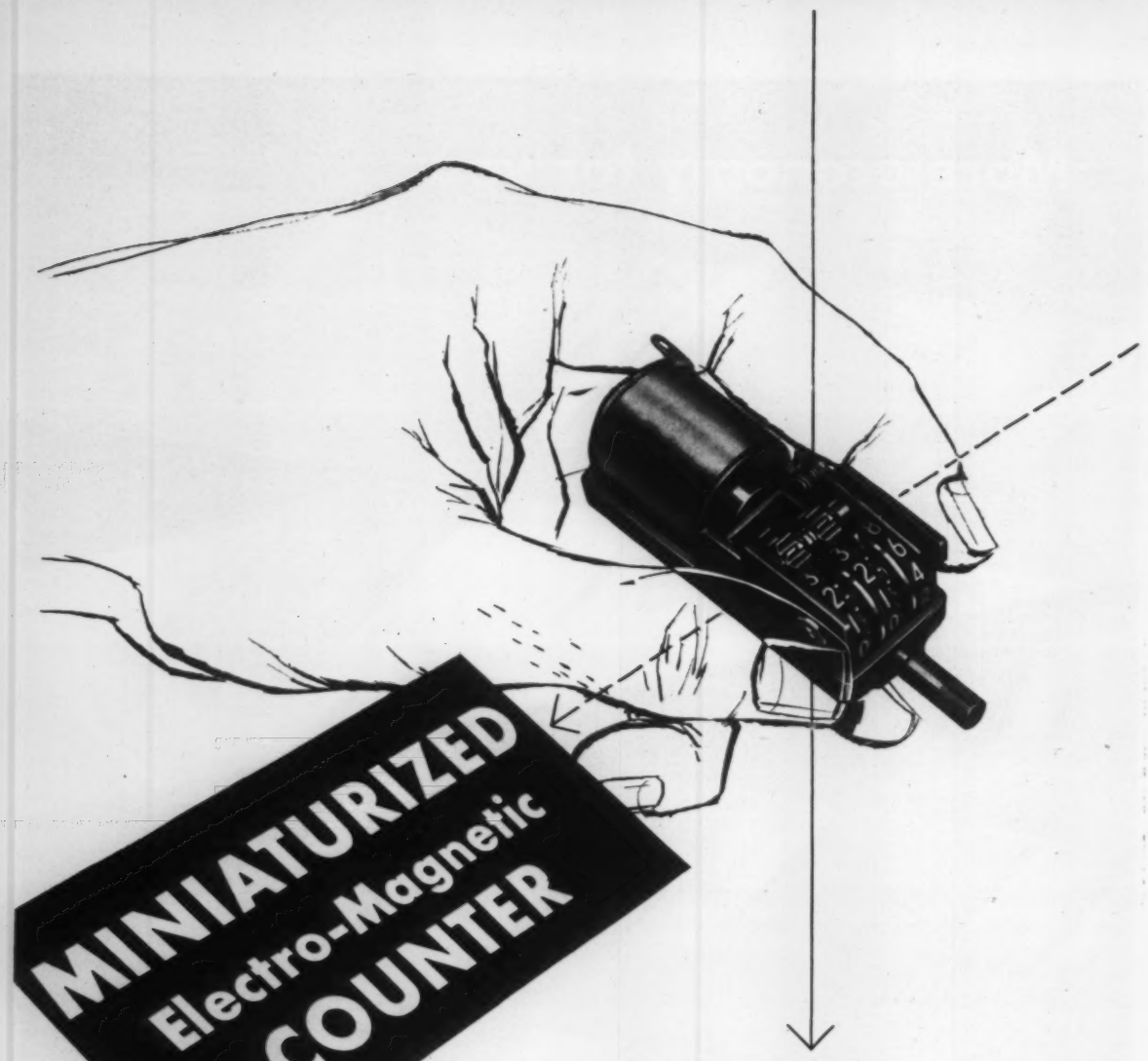


Newest News from
VEEDER-ROOT

Series 1527 Veeder-Root Miniaturized Electro-Magnetic Counters were originally developed for use in aerial cameras. These and similar counters are used to "post" the number of film-exposures, gallons or rounds of ammunition remaining after each use.

The new miniaturized counters present a frontal area less than 1" x 1" . . . save an important amount of space over the older, larger counters. Yet they are designed to operate at speeds as high as 900 counts per minute. And this modern design includes a new push-in bi-directional reset knob, with speed-up gearing. Specifications meet most military requirements. Write for full details.

Added Evidence that Everyone Can Count on

VEEDER-ROOT
INCORPORATED
HARTFORD 2, CONNECTICUT
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

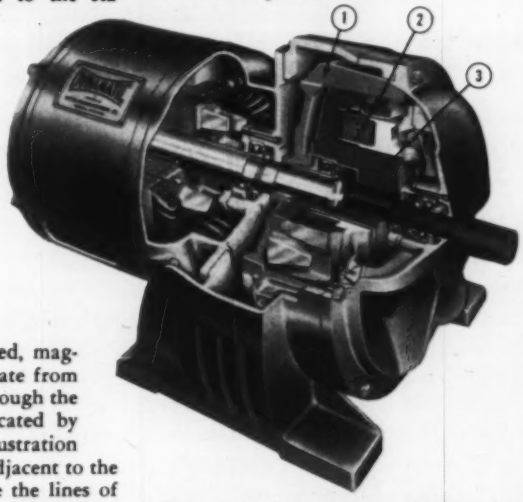
Circle 480 on Page 19

HOW DYNAMATIC® Drives Provide Infinitely Adjustable Speed with AC Power

Dynamatic Ajusto-Spede® and Dynaspede® Drives operate from an alternating current power source and are infinitely adjustable from zero RPM to full output speed. Accurate control of output speed is obtained by varying the current in a single field coil.

Each Dynamatic Drive consists of a constant speed AC motor and an eddy-current coupling. Torque developed in the motor is transmitted through the coupling by electromagnetic attraction between its driving and driven members.

The driving member, or drum (1), is mounted on the end of the motor shaft and surrounds the rotor, or driven member (3). The drum is free to rotate independently of the rotor until current is applied to the stationary field coil (2).



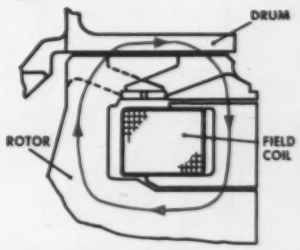
1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

As the field coil is excited, magnetic lines of force emanate from the field coil and flow through the rotor and drum as indicated by arrows in cross-section illustration (A). Poles on the rotor adjacent to the smooth drum concentrate the lines of force into localized areas of "high flux" density in the drum's inner surface, shown in illustration (B). As the drum rotates about the rotor, these high flux areas sweep the inner surface of the drum, causing a variation of flux density that generates an eddy-current field in the drum's inner surface. Magnetic attraction between this eddy-current field and the rotor poles causes the rotor to rotate with the drum.

The torque transmitted from the drum to the rotor varies with the current applied to the field coil and with the "slip", or difference in speeds between the drum and rotor. Speed control with eddy-current equipment is obtained with a control system that adjusts field coil current to deliver the required torque at the desired slip.

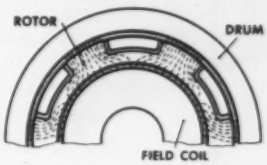
The control systems used with Dynamatic Eddy-Current Equipment operate on alternating current and require no special power source. Because of the low power required for field coil excitation, rectifying of field coil current is easily accomplished electronically. Expensive motor-generator sets are not required.

The control features available with Dynamatic Eddy-Current Equipment include constant speed regulation, acceleration control, torque regulation, cascading of multiple units, inching and threading, and numerous others as required by individual applications. Dynamatic Eddy-Current Equipment is ideally suited to automatic control.



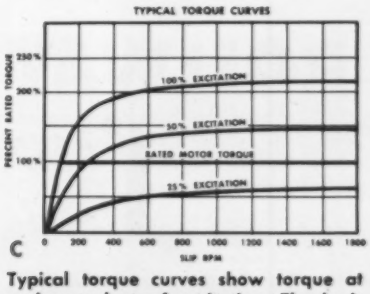
A

Flow of magnetic lines of force through rotor, drum, and stationary field.



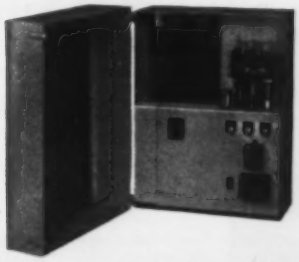
B

Concentration of magnetic lines of force by the rotor poles.



C

Typical torque curves show torque at various values of excitation. The horizontal line is rated motor torque.



D

The electronic control systems used with Dynamatic Eddy-Current Equipment do not require a special power source or motor-generator sets.

Send for your copy of Bulletin D-582 which gives detailed information on Dynamatic Eddy-Current Equipment.

EATON®

EATON DYNAMATIC DIVISION
MANUFACTURING COMPANY
CLEVELAND, OHIO

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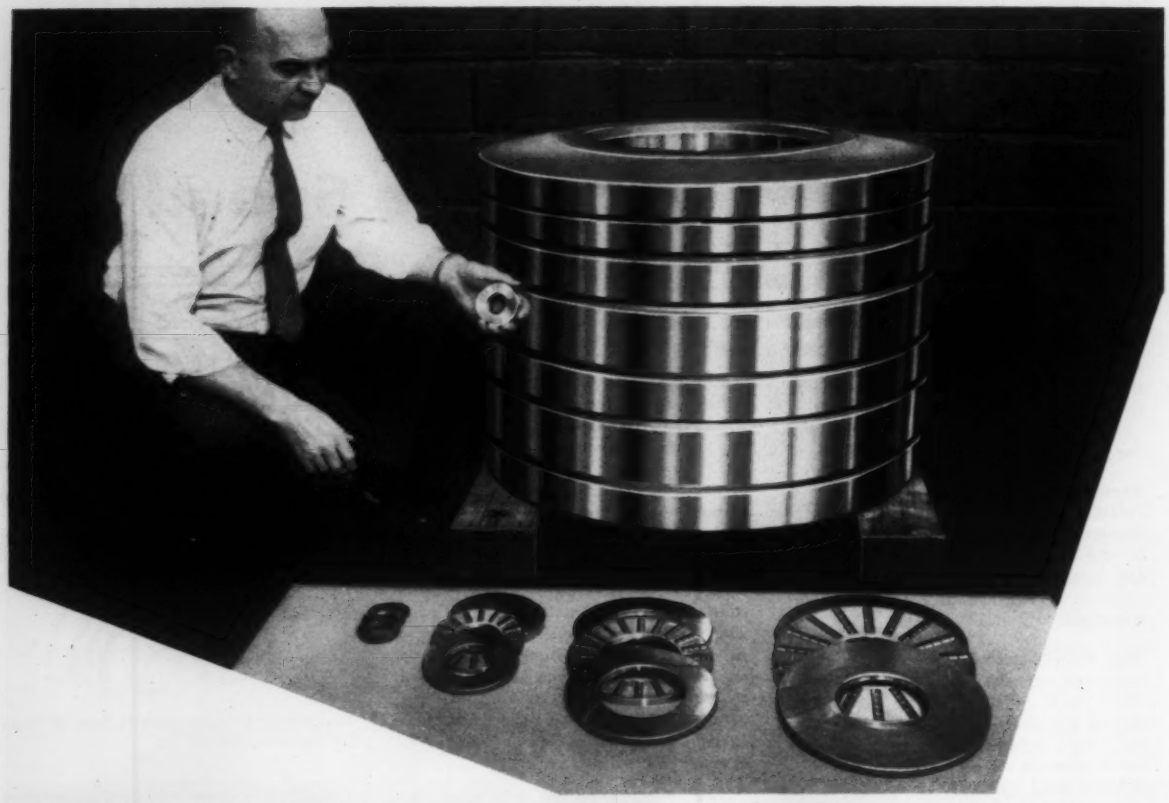


ROLLWAY THRUST BEARINGS...

$\int_{2''}^{36''}$ *Design + precision + quality that do the job in the one best way...*

Size in Rollway Thrust Bearings—big or little—is a mere matter of operating "geometry" and of the machinery to produce it. But design, precision and quality are dimensionless quantities that vary widely according to loads, speeds, temperatures . . . yet in the end sum up to a single constant: *"To do the job required in the one best way."*

Of course, we're proud of this 2¼ ton bearing with its thrust load capacity of 4,630,000 lb., its diameter of almost 3'-0" and its 3 roll assemblies with 6 precision thrust plates matched to equalize load and deflections for each stage. But we're equally proud of the little 2 incher in Design Engineer Grigson's hand. Despite the great difference in size, each has been carefully worked out *"to do the job required in the one best way."*

Whether you want a bearing for an oil rig, an extruder, a pulp mill jordan, a crane hook, a heavy duty lathe and countless other uses, Rollway has one that will do the job "in the one best way."

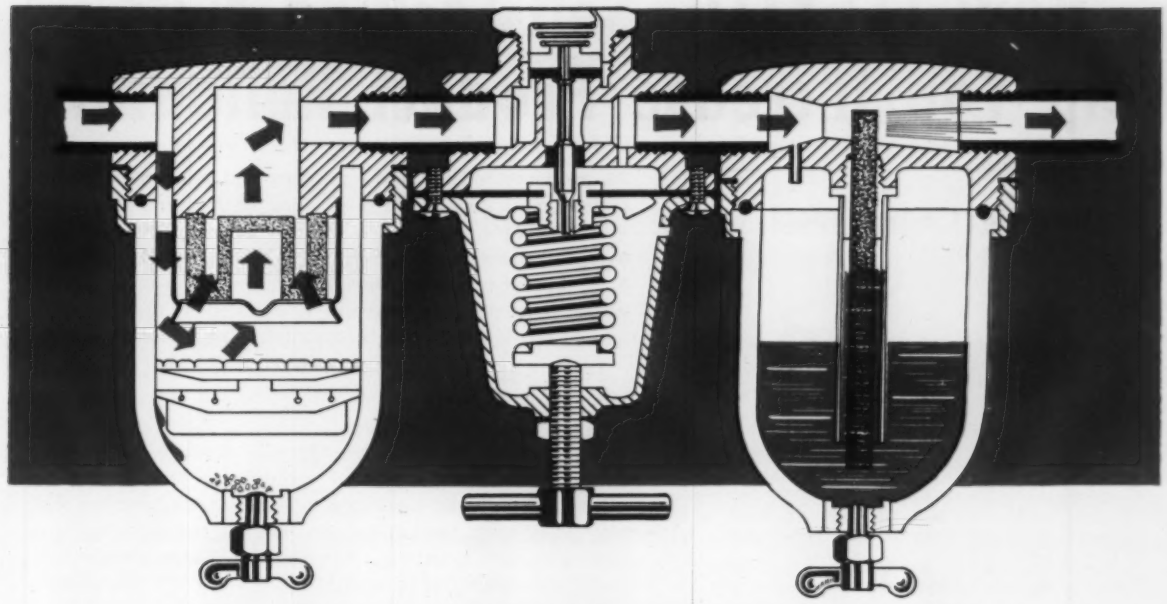
5 Standard Types:

- Single aligning
- Double aligning
- Tandem
- Single acting
- Double acting
- Special-purpose types to your order

See us at Booth No. 673
Design Engineering Show—Chicago

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco



Three-way protection in one package

GARDNER-DENVER AIR LINE

filter—regulator—lubricator

This easy-to-install combination assures a continuous supply of clean air at desired pressures, provides proper tool lubrication. The assembly utilizes a straight-line air flow principle with low pressure drop throughout the system—less than 1 psi at maximum rated capacity.

Protect air-powered systems you design with a compact and relatively inexpensive Gardner-Denver filter-regulator-lubricator combination. Individual units also available. For complete information on the Gardner-Denver 3-way air line protection package, write today.

FILTER removes moisture, solid matter and rust scales from the air line. Features air passage area of a size to minimize pressure drop.

REGULATOR holds line pressure at the exact level desired . . . assures instantaneous response to demand changes at the point of use.

LUBRICATOR injects a fine mist of oil into the supply line, providing the valves and motor parts with a constant protective film.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

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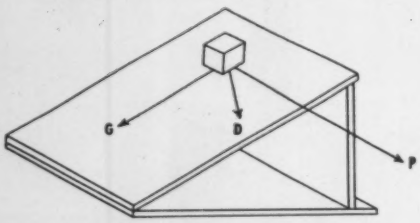
How FLEXLOC Self-Locking Nuts Help You Increase Product Reliability

WHY A NUT WORKS LOOSE



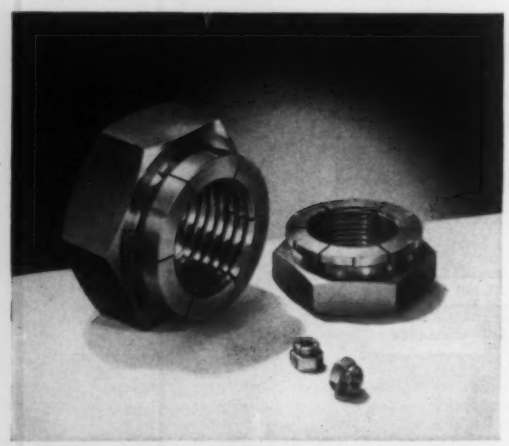
The reason why a nut works loose under vibration is best explained by the analogy of a free block on an inclined plane. Up to a certain angle of the plane, friction keeps the block from sliding (G). But if an external force starts to move the block sideways (P), friction can be reduced to the point where the block begins to slide down at the same time (D). A similar action occurs with screw threads. Tightening a nut forces its thread "uphill" against the thread of the screw or bolt. This sets up tension, creating enough friction between mating threads to hold the nut tight —under some conditions. Often, however, vibration causes marked variations in screw or bolt tension, resulting in motion between mating threads to the point where they begin to slip past one another or "run downhill." Result: creeping rotation of the nut and eventual loosening.

As products become more complex and more highly automated, mechanical failures become both more costly and more probable. As a result there is growing concern today over the problem of reliability, not only in the industrial field, but also among manufacturers of consumer goods, whose customers are increasingly irritated by the whopping annual repair bill on their automobiles and home appliances.

Faced with this demand for greater reliability, more and more manufacturers are adopting the rule of thumb that any bolted assembly subject to impact, shock or vibration will eventually loosen unless secured by a positive locking device. The trouble is that conventional locking devices are not always reliable. Lockwashers sometimes snap; jam nuts may work loose themselves; and cotter pins or wiring may permit partial loosening. Furthermore, these devices take extra time and labor to install.

FLEXLOC self-locking nuts offer you a simple, practical way to reliable, vibration-proof fastening. A FLEXLOC is a 1-piece, all-metal, self-locking unit requiring no auxiliary locking elements. There is nothing to put together, come apart, or get lost; there are no inserts to pop out or deteriorate. FLEXLOCs can be used as locknuts or stopnuts. They lock, seated or not, wherever wrenching stops. They will not vibrate loose, yet are easily removed and can be used repeatedly.

See your authorized SPS distributor for more information. He carries FLEXLOC self-locking nuts—regular and thin height—in a full range of standard sizes and materials. Or write Flexloc Locknut Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.



One-piece, self-locking FLEXLOCs require no auxiliary locking devices, no extra time or labor to install. Seated or not, they lock wherever wrenching stops . . . won't work loose.

hiR
High Reliability factor

At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic forces. By using SPS fasteners in your assemblies, you increase overall reliability—the certainty of predictable performance under actual service conditions.

Write for a copy of the current SPS booklet "Concerning High Reliability"—an introduction to the new science of reliability engineering.

We also manufacture precision titanium fasteners / write for free booklet

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Save 27% or more in cost...

NEW

Miller

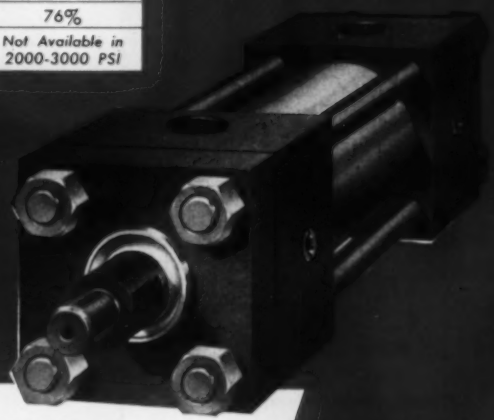
"JOB RATED"

HYDRAULIC CYLINDER LINE

JOB RATED, MODEL " J "

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	Not Available in 2000-3000 PSI

with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.



SEAL FAILURE MEANS CYLINDER FAILURE!

1. *No seal made of synthetic rubber is compatible with even 50% of available, commercial, petroleum base hydraulic fluids.*

MILLER Uses All Teflon* Seals to Eliminate External Oil Leakage because Teflon is impervious to all known hydraulic fluids, even fire-resistant types.

TEFLON SHEF SEAL At Tubing Ends

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON Seals On Piston Rod And Bushing

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON Seals On Ball Check And Adjusting Screw

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

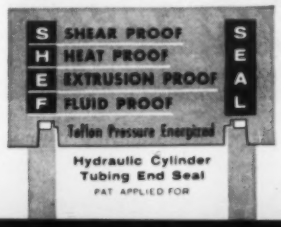
MILLER Uses Resin-Impregnated Leather Piston Cup Seals because they are compatible with petroleum base fluids and some fire-resistant types. Teflon cups available at small extra cost.

2. *Nicked or scored piston rods cause seal failure*

MILLER Uses Case-Hardened Chrome-Plated Piston Rods because they prevent nicks, scoring and rust.

NOW! . . . You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program as the Power-Packed Line (2 hours if necessary—3 days normal).

*On Plant Materials for tetrafluoroethylene resin which withstands temperatures from −100° F. to +500° F. and all hydraulic fluids.



OTHER MILLER QUALITY FEATURES
- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Precision Honed Barrels

Circle 485 on Page 19

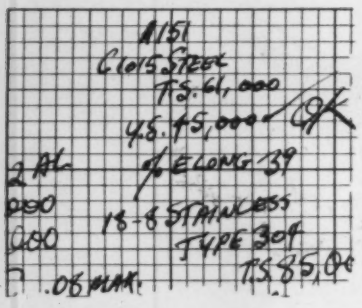
MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION

2006 N. Hawthorne Ave. Melrose Park, Ill.

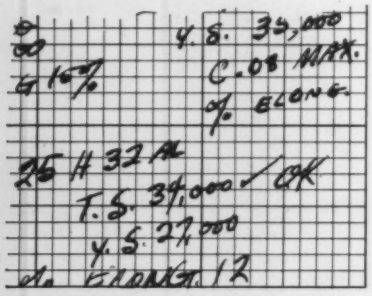
AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

How strength can be designed into component parts

Only the stamping method of production offers such an unrestricted latitude of material selection. With stampings, strength can be designed right into a product or component part. It can be specified into the basic material and improved during the stamping process . . . it can be predicted, controlled and maintained. Strength in stampings can, in fact, be higher in proportion to weight than is possible in any other metalworking process.



All parts, pieces or units are designed around their predetermined end use. The end use pretty much dictates the material to be used in making the component. Only in stampings are the metal, finish and inherent characteristics of the part completely controlled and established beforehand by the design demands. With stampings, there is no need to sacrifice strength to gain other desirable properties. And in stampings, strength is achieved and not just approximated.



Durability is another quality inherent in every stamping. Because stampings are not fragile, they will not break or crack even when thrown out of line or dented by careless handling.

The resilience which characterizes stampings adds to their versatility in production, shipping, finishing and to the manner of their final assembly with other stampings, other component parts, to form a finished product.

Stampings Keep Clutches Rigid

COMMERCIAL close-tolerance stamped housings—ten sizes up to 40 inches in diameter—maintain dimensional accuracy in clutch and brake construction

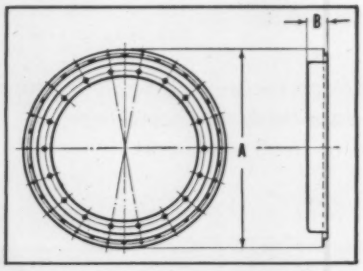
Because the side housings of the Fawick Airflex Type E clutches are stamped to close tolerances, no costly machining is required before assembling.

This unique clutch puts all the load on torque bars which rest on the stamped housings. The clutch design takes full advantage of the inherent strength of the positioned steel.

The Fawick clutch assemblies are used in a wide range of sizes for clutch and brake applications in heavy-duty original equipment. COMMERCIAL has been supplying the stamped housings for the assemblies since 1944 when they first designed and built the original dies.

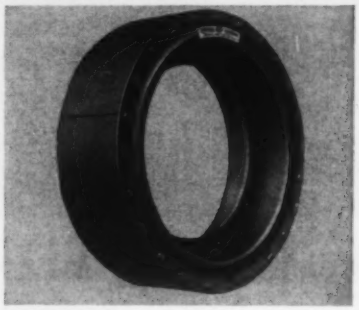
Close tolerances on pierced holes and slots insure perfect alignment of mating parts in final assembly.

Gang piercing provides the required dimensional and location accuracy of holes and slots without the cost of multiple drilling. Slotted openings with integral tabs are formed without metal fracture. The sharp bottom radii and straight sidewalls require a deep draw. Yet, close tolerances must also be maintained on these dimensions.



A	11⅞	13⅞	15⅞	18⅞	21⅜
B	2⅝	2⅝	2⅝	2⅝	2⅝
A	23⅞	26⅞	29⅞	33⅞	39⅞
B	2⅝	2⅝	3 11/32	3 11/32	3 29/32

Typical tolerances in the Fawick stamped housings are +.005" − .000", +.005" −.005", +.000" −.010" Special notes on shop drawings call for all holes equally spaced, within tolerances of plus or minus .005" while parallel surfaces are maintained. COMMERCIAL'S ability to meet such stiff stamping requirements reflects its skill and experience in handling unusual metal forming problems.



Fawick's non-mechanical drum-type clutch requires the accuracy of COMMERCIAL stamped housings when continuous pressure is applied.

These clutches in use on power shovels, locomotive cranes and other heavy-duty equipment, keep the load from slipping through friction The housings stamped by COMMERCIAL withstand the load and the heat generated by the friction involved, yet maintain the alignment and accurate dimensions to which they are stamped.

If you have a design problem involving component parts, we may be able to suggest a practical and economical solution based on our 30 years experience in forming metals. Send details of your problem to Commercial Shearing & Stamping Company, Dept. S-12, Youngstown 1, Ohio.

COMMERCIAL
shearing and stamping

CUSTOM-DESIGNED AND MASS PRODUCED TO YOUR PARTICULAR REQUIREMENTS

Dot plug buttons were originally used in automobiles to fill spaces on standard models which, on de luxe models would be occupied by such extras as cigarette lighters, radio controls and so on. They are now also widely used as lenses for indicator lights and as identification buttons on instrument and control panels of all kinds.

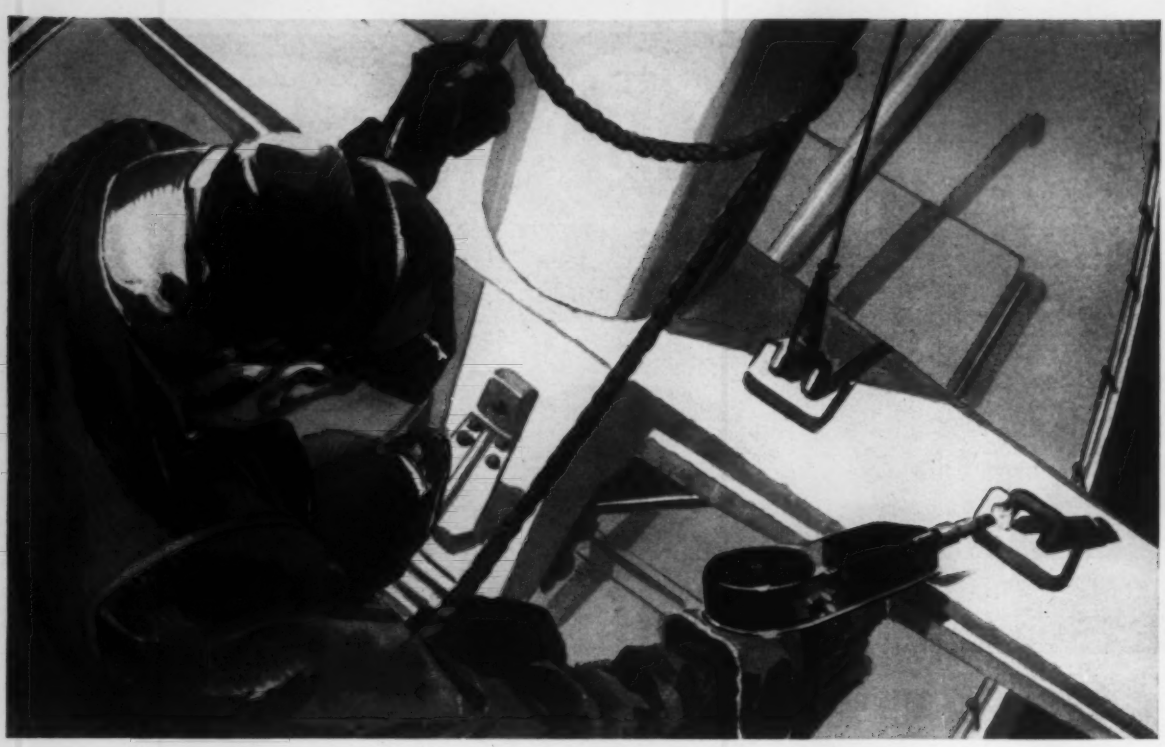
Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

CARR FASTENER COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION 31 Ames Street, Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

Circle 487 on Page 19



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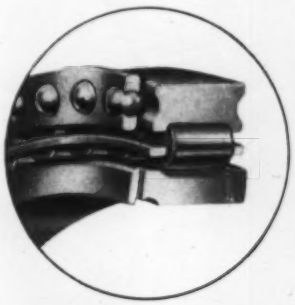
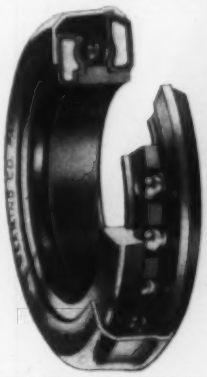
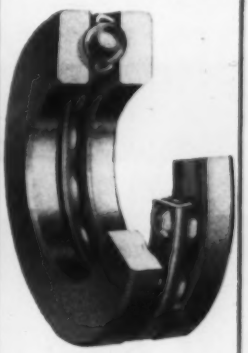


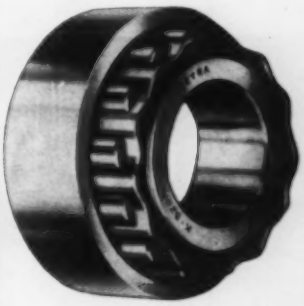
COMBINATION ROLLER AND BALL BEARING



CLUTCH RELEASE BEARING



THRUST BEARING



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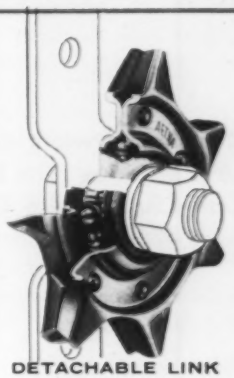

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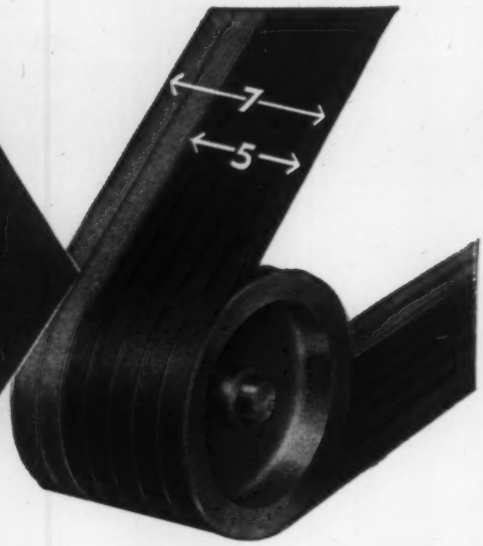

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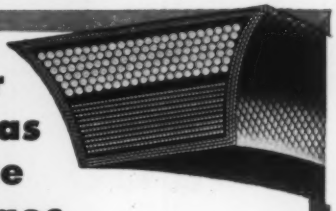

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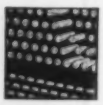

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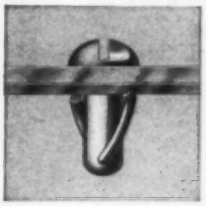

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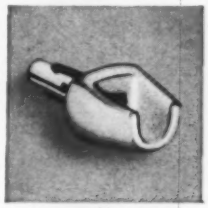

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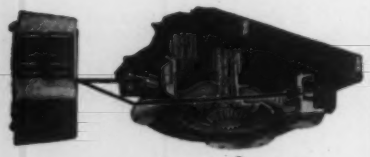

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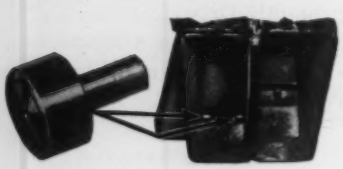

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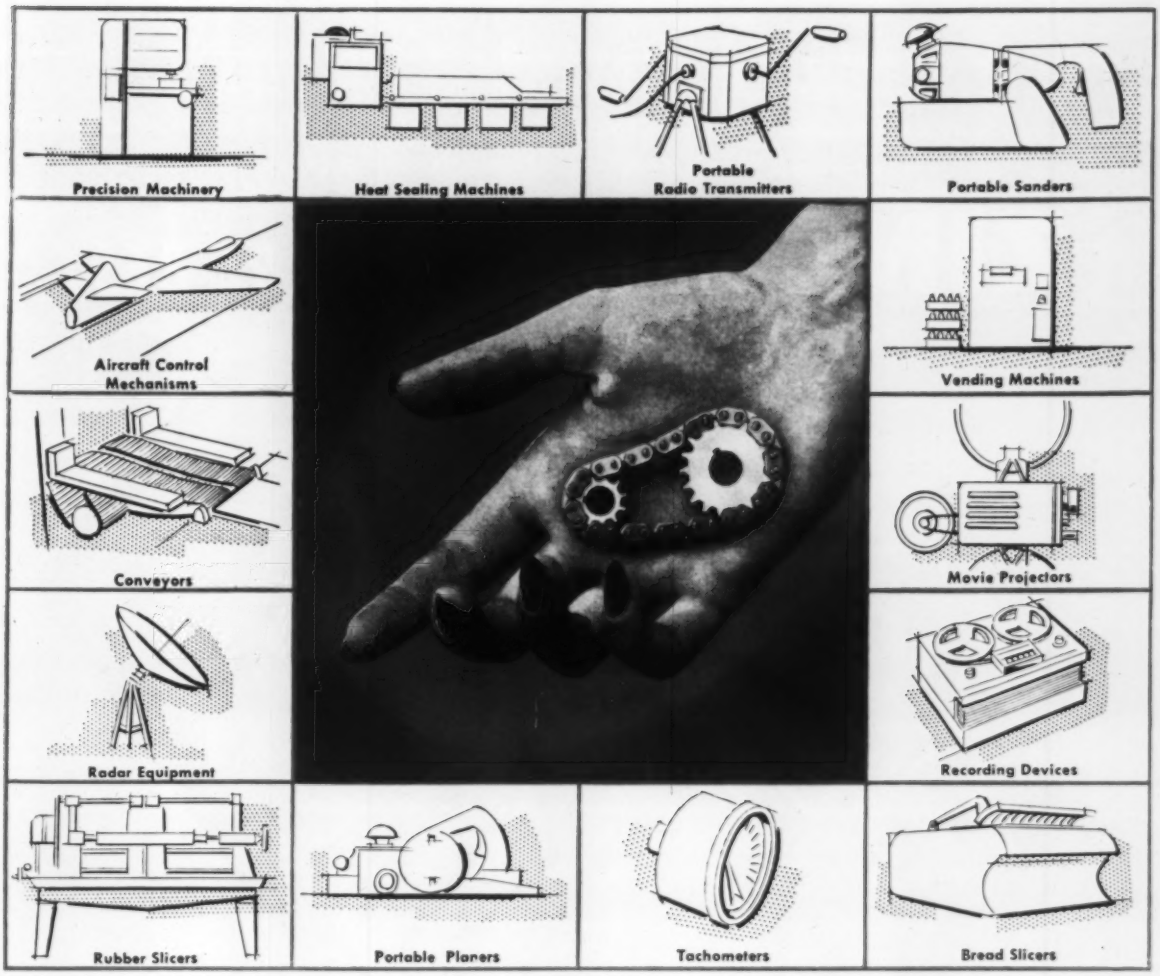

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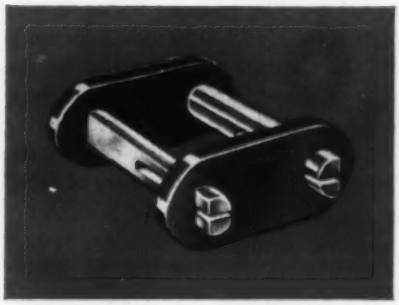

EXCLUSIVE!

Patented coupling link makes assembly and removal of Morse 3/16"-pitch Silent Chain easy, permits design of fixed center drives without assembly problems. Your Morse distributor can supply you with exact lengths needed; or you can buy chain in bulk, cut it to size, assemble it yourself with easy-on coupling links.

Trying to get more components into less space? Morse 3/16"-pitch Silent Chain helps you do it—often saves you money, too!

Tiny, but with the strength of steel, these highly efficient drives transmit power as smoothly as a belt at speeds up to 10,000 rpm. Split-second precision of drive frequently permits replacement of costly gears.

You can get Morse 3/16"-pitch Silent Chain in every standard style: shroud, center guide, or duplex; special chain materials are available for use in corrosive or extremely wearing conditions. For skilled engineering help on power transmission in limited space, call your local Morse distributor today. He's listed in the Yellow Pages under "Power Transmission." Or write: *MORSE CHAIN COMPANY, DEPARTMENT 6-38, ITHACA, NEW YORK; Export Sales: Borg-Warner International, Chicago 3, Illinois.*

IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

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FOR *Extremely Complex Shapes*
AND *Close Tolerances*

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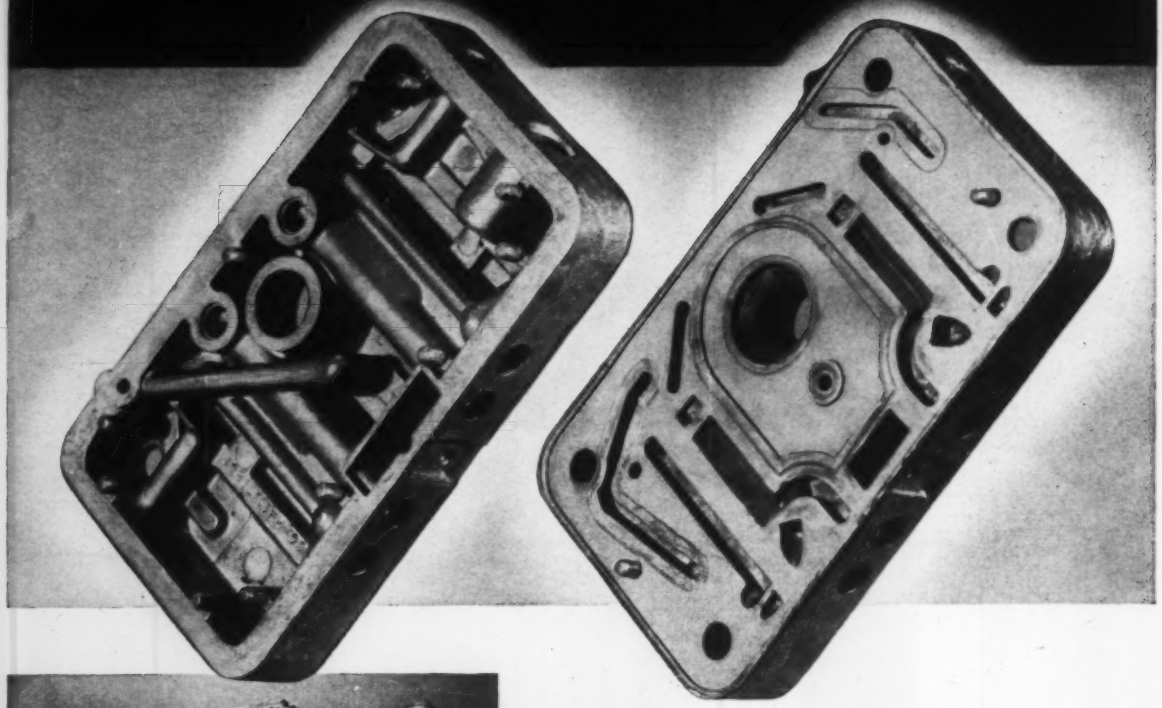

14 ZINC Die Castings make up principal components of the Holley four-barrel downdraft carburetor.

HOLLEY Carburetor Co. has these exacting metering bodies as well as 12 other principal parts of the Model 4150 carburetor made of ZINC because ZINC Die Castings are best suited for the job. Extreme complexity of shape of all these components, close tolerances of the air and fuel passages in the metering bodies and rigid efficiency requirements of the product demand the accuracy, strength, reliability and economy of ZINC Die Castings.

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DESIGN
March 20, 1958

Custodians of Brainpower

ECONOMIC slowdowns coupled with evidence of scientific lag have jolted the country sharply out of its complacency. But we still seem reluctant to take the approach which is uniquely American and which has put us ahead of nations with greater population and natural resources. That approach is to challenge the individual.

For instance, we look abroad and see a Russian educational system turning out hordes of so-called scientists and engineers. So we clamor for government aid to education here. For a country which traditionally has stressed individualism we are surprisingly collective in our approach. It's always, "the government should . . ." or "why don't they . . . ?"

We have engineering brainpower—now. And with a little more care and effort in finding and steering those with engineering aptitudes into our present educational system, there should be adequate supply in the future. But how efficiently is that brainpower being utilized—by its owners and by its employers?

Every engineer has a good, educated mind; otherwise he wouldn't be where he is. But how many possess genuinely prepared minds, minds with the circuits to tackle and solve tough problems? How many constantly broaden their knowledge and outlook beyond the narrow confines of today's job?

If there has seemed to be a shortage of engineers, perhaps it is because not all of those available have been willing to forego some of their favorite pastimes in order to maintain the broad-scale effectiveness of their minds. And if management has wasted engineering talent on routine jobs, could it be because some engineers seem to have fitted themselves for little else?

Of course we need the routine capabilities of mass-trained minds. But the major breakthroughs, the unscheduled leaps ahead, have come from individual, prepared minds. As custodian of his own mind, each engineer is responsible for keeping it prepared to meet every challenge.

Colin Carmichael

EDITOR

The hue and cry is for more and better creative thinking. But is it really wanted?

This question arises because organization policy and personnel relationships produce an atmosphere which stimulates creativity —or, all too often, smothers it. Thus, social situations in which people work are no less important than thought processes involved in problem solving.

Here's how a professional psychologist looks at the problem.

UNLOCKING HUMAN CREATIVITY

By RICHARD W. WALLEN*
Director, Managerial Training Div.
Personnel Research & Development Corp.
Cleveland, Ohio

IN THE business world, interest in "creativity" has soared to the heights of fadism. The crop of articles and brainstorming demonstrations is symptomatic of the craze. Like most fads, there is more interest in the trick, the gimmick, and the quick result than in fundamental ideas. For example, the term "brainstorming," once intended to apply to a specific method, is now being used for any session where people are asked for suggestions. Undoubtedly, we can help people become more creative. But it will not be done by cute tricks.

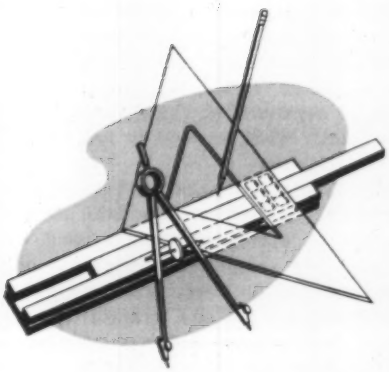
WHAT do we mean by creative thought? Essentially, creative thinking produces a novel solution to a problem, or formulates a novel problem requiring solution. In fact, high-level creative thinking poses problems that may require years for their solution.

Ordinarily, we speak of creativity as if it were something apart from everyday life. It is thought to be an ability found in very few people. Actually, this is not true. Creative thinking varies greatly in quality and scope. Of course, only a few people have the intelligence, training, temperament, and supporting social environment to write great plays, create symphonies, or remold scientific theory. But many people can find solutions that are novel within the range of their own experience. A child can be creative, inventing games or stories he has never been taught. The essence of the creative act, then, is that it goes beyond the familiar, the known, and the remembered.

Not all outcomes of creative activity are useful or important. What is it that makes a thing useful or important? Basically, it is popular acceptance. When the outcome is accepted by many people over a long period of time, or when it radically changes the thinking of experts for many years, it is significant. Most of us could write a poem, and a few could get it published. But we would not reach an audience as wide as that reached by Keats or Walt Whitman. You may create something that is novel for you, but if other people do not regard it as novel or valuable, it is not regarded as creative.

Significant creativity, then, depends not only upon the individual but upon society. It depends upon the interest society has in the solution, invention, or artistry created by the individual. Many highly creative musical compositions were hissed and booed by the audiences who first heard

*At the time this article was prepared, Dr. Wallen was Senior Associate with Creelman Associates, Cleveland, Ohio.



them. Today, they are regarded as masterpieces. Were the composers less creative when they were ridiculed than when they were applauded? And would they have been more creative if they had tried hard to please the audiences of their times?

INDUSTRIAL organizations are not really interested in all-out creativity. They are interested only in creativity that leads to profit-making products. This is certainly a legitimate interest. But it does raise a serious question: "Could the requirement of profitability, in itself, deter genuine creative activity?" I suspect that the answer is "yes." I suspect that, deep down, industrial executives do not really want creative people. And I think this is not hard to understand.

Essentially, creative activity is rebellion against things as they are and have been. It is a kind of nonconformity. It springs from a dissatisfaction and criticism of the existing order. Now, can a man be a rebel in machine design and still possess conforming attitudes in all the other areas of his life? We do not really know the answer to this question. It is a fair guess, however, that many genuinely creative people do not fit very well into the necessarily organized routine of industrial research laboratories. And a strong emphasis on the creation of profitable products may hamper the vision and free-ranging imagination needed for creative activity.

LET us consider more specifically the nature of creative thought. What does a person do when he is thinking creatively? One process consists of the linkage or association of ideas that are not necessarily connected. One thought is forcibly joined with another. For example, imagine an elephant with three-inch yellow triangles pasted all over it. Can you visualize that? In some sense, this is creative thought. It is not a very good idea, but it is new. This linkage device can be applied in many ways. The linkage of a clock and a radio produced a profitable product. We can apply this artificial association method to all kinds of objects. What would happen if we tried to link can-openers with file cases, automobiles with coffee pots, book cases with motor oil?

Another variation is to make extreme changes in a known process or mechanism. What would happen if we made something as large or as small as possible? What would be the value of a recording machine as small as a dime? What could it do if it were as large as a house? Or we can make extreme changes in the rate of motion. What would be the consequences of trying to make an automobile go 1000 miles an hour? Or we can try reversing the direction of power. For example, what would happen if we reversed the direction of power in a typewriter? Could the sheet of paper push the type bars and depress the keys? What uses would such a machine have? Undoubtedly, a number of new ideas can be developed in this way, and some of them may be useful.

A higher level of creative thought consists of seeing similarities among situations that are apparently different. In this activity, the creative thinker penetrates below the surface of objects and processes. He discovers inner meanings, finds analogies, and discovers surprising identities.

We can see this kind of thinking quite easily in poetry. Take an example from a poem by John Keats. Here you can see the kind of imagination it takes to discover similarities in things that seem remote from one another. In one stanza, Keats begins: "Oh, for a beaker full of the warm south," and he continues, "with beaded bubbles winking at the brim." Do we have the imagination to notice popping bubbles along the edge of a glass and think of eyes winking? It takes a high order of poetic imagination. In this kind of thinking, there is no artificial linkage of ideas. Rather, there is an intrinsic connection, a suitability, or fittingness that occurs only to a free-ranging mind. Creative thinking of this kind requires a person who thinks beyond literal interpretations and surface appearance. Perhaps this is why children can speak poetically without realizing it. Thus, a little girl, not yet three, watched the rain begin to fall and

remarked, "The clouds are crying." If we are bound by what is useful, practical, and socially correct, we may never explore the distant field of fanciful and creative thought.

I want to describe this kind of thought by saying that, in it, objects and ideas shift into new configurations. This differs from the artificial association of thoughts. In that process, ideas remain the same, even when linked together. But when a configuraton changes, the ideas themselves undergo an alteration. Things do not remain as they are; they change by being brought together. Here is a simple illustration of this transformation: A man wants to hang a picture but has no hammer. As he looks around the room, he finally sees a metal paper-weight. At this moment, the paper-weight is transformed into a hammer, and he now uses it in a way he has never done before. So, too, a child confronted with two large blocks and two small ones often describes them as a family: a mother, a father, and two baby blocks. From his limited experience, he combines his concern for size and for human relationships, and thus transforms blocks into imaginary people.

LET us further examine this shift of configurations. I want to pose a simple problem that illustrates it beautifully. A farmer had four pieces of chain, each consisting of three links. He took it to a blacksmith and said, "I want you to weld these pieces into a circle of chain. How much will it cost?" The blacksmith laid the chain out in the pattern in Fig. 1. He told the farmer, "I charge 50c to break a link of chain, and 50c to weld it back again. Since you have four corners, it will cost you $4.00." The farmer replied, "That's too much money. Actually, you can do it for $3.00." The problem, then, is to construct a circle of chain, breaking and welding only three links.

I want to show you how this problem can be solved by a shifting of configuration. We shall see, visually, a reorganization in thought. During this reorganization, one of the elements is transformed into something new. Fig. 2 shows the first step in one possible reorganization. Here, three segments of chain are kept close together. The fourth is separate. Some people immediately see the solution when the chain segments are arranged this way. But let us go further in reorganizing the pattern.

Fig. 3 shows three chain segments now arranged in the form of a triangle. This figure has only three corners. Perhaps a solution is possible! But what shall be done with the chain segment that has been separated from the others?

In Fig. 4, the next to the last step has been taken. The troublesome separate segment is no longer seen as a chain, but rather as a stockpile of individual links. It is easy to see that one of the original segments of chain vanishes. Three links are exactly what we need to join the three corners of the triangle.

The important point in this demonstration is that, for a reorganization to take place, the original pattern of systematic arrangement must be destroyed. Of course, not every form of destruction will solve the problem. For example, if four segments are laid out in a straight line, that does not help. A person may think of a variety of arrangements before he discovers the one shown in Fig. 3. But the trial and error process cannot take place unless the elements of the problem are broken up. The reorganization takes place by an activity that we might call a "playful juggling" of the parts of the problem. I shall return to this process later.

In the chain problem, the solution does not take place by the addition of a new idea. It is not done by pasting associations together. Rather, there must be a basic change in the structure of the parts. Novelty arises through a new set of relationships rather than by adding new ideas. This is probably what happens in creative thinking of a high order.

ANOTHER example of the difference between reorganization and the mere adding of ideas can be demonstrated by using Fig. 5. People usually make something of these lines: The bare branches of a wind-blown tree, a part of a street map, a sketch of some peculiar tool, or part of a circuit diagram. Now I want to tell you the real storv behind these lines.

A young man had a dog that was very fond of him. When the man enlisted in the Army, the dog went along. He followed his master everywhere. When the young soldier walked his post on sentry duty, the dog was with him. These lines show part of the rifle and part of the dog after the soldier had turned the corner of a building.

Does this story simply add a new idea to the lines in Fig. 5? Is it the same thing as pasting yellow triangles on an elephant? No, indeed. The story transforms the lines into a new structure. The

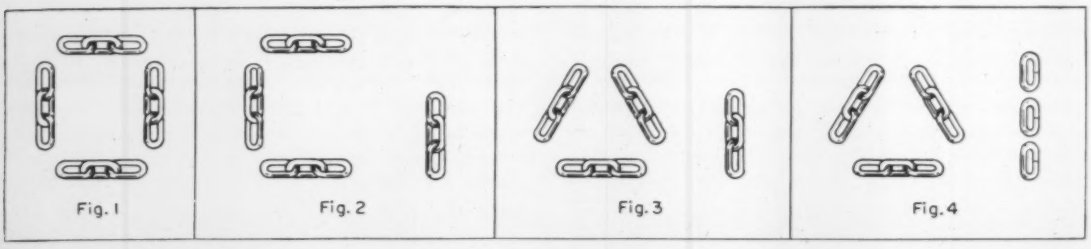
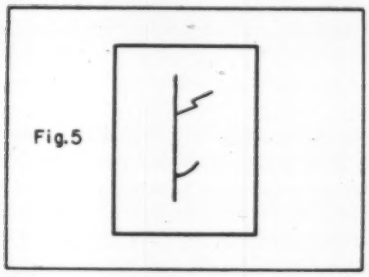


Fig. 1 Fig. 2 Fig. 3 Fig. 4

space to the left of the vertical line is no longer seen as empty, but as solid. The small curved line no longer is seen as joining the vertical line. Rather, it extends behind it. A restructuring has taken place.

Can this conception of creative thought as reorganization help us be more creative? Yes, but before we turn to practical matters, we must consider two additional ideas about configurations. The first of these is the concept of self-regulation, and the second is the concept of closure.



A SIMPLE example of self-regulation is found in a soap bubble. As it floats freely in the air, the bubble tends to assume a completely spherical shape. The sphere has a minimum surface area for a given volume. This condition is the end-state, or final equilibrium, of the bubble. A sudden breeze may distort it, but it tends to move toward its own end state. Another example is the action of a compass needle in a magnetic field. The needle moves toward a particular position. A mechanical constraint can prevent the needle from reaching this end state, but even then, the needle presses toward it as far as the constraint permits. It seems quite probable that this self-regulating quality occurs in thinking, too. Our concern for symmetry, regularity, and periodicity in natural laws and in art may be due to the tendency of thinking to move toward certain kinds of end states.

Now, dynamic systems that lack a needed part tend to rearrange themselves to form a new equilibrium. A gap tends to be filled unless mechanical constraints are interposed. Thus, air tends to rush into low-pressure regions, and rivers run toward the sea.

In genuine configurations, a gap seems to be filled only in a particular and suitable way. Imagine a circle with a small arc omitted. When people are asked to complete this figure, they rarely draw a straight line joining the two end points of the curve. The usual completion is a line with the same curvature as the circle. This is felt to be "fitting" and somehow "appropriate." For a square, with one corner omitted, the suitable completion will not be a curve, but rather a right angle. We can say that the figure itself calls for a particular answer. Any other completion is felt to be "wrong." I am suggesting that the process of creation works in this way. A problem is a configuration with a gap: the solution. Under certain conditions, the parts of a problem arrange themselves so as to call for the correct answer. Of course, I am referring here to the physiological processes which underlie thinking. But since these are unknown, it is more convenient to refer to them as ideas, knowledge, or parts of the problem.

This is a bold hypothesis but not a foolish one. One of the most frequent reports from people who have studied their own creative thought is the sudden appearance of the solution. Their reports indicate that the novel idea came without effort. Usually, its appearance was unexpected. On these points, we have the testimony of scientists like Helmholtz, philosophers like Bertrand Russell, and musicians like Beethoven. Of course, we must not overlook the fact that these "moments of insight" have histories. We know something about the events that take place before spontaneous and creative ideas arise. What precedes the sudden solution?

APPARENTLY, there are at least three requirements for creative insight. The first of these is fascination with a problem. I choose the word "fascination" because it expresses the sense of captivation and irresistible attraction experienced by the thinker. Somehow, creative people just cannot let go of certain problems or types of problems. Why is fascination a necessary requirement? We shall find the answer by looking at the second requirement for creative thought.

The second essential, particularly for creative scientific thinking, is saturation. I mean saturation with the facts, with technical ideas, with data, with the background of the problem. There must be so much familiarity with a particular problem that we don't need to look up drawings or hunt a book. The facts must be easily available. Acquiring this background takes time and effort. It may take years. Now, perhaps we can see the need for fascination. It is needed to hold the creative thinker to the long and difficult task of learning about the problem. Without it, he would give up too soon, and some of the ingredients for the final solution would be missing.

The third essential for creative insight is a period of reorganization. Once you have finally saturated yourself with facts and ideas, they must have a chance to rearrange themselves, to shift into a configuration that points toward solution. Apparently, during the period of saturation, certain attitudes, beliefs, and useless notions are acquired that prevent the facts from shifting into a new pattern. Something must be done to weaken these obstructions. There must be some way of permitting the relevant data to organize themselves, unhampered by irrelevant constraining forces. The testimony from creative people tells us that in this period of reorganization there is no conscious concern with the problem. The moment of insight

appears in the midst of relaxation or even sleep. It occurs when the creative person has been occupied with leisurely enjoyment, when little was required of him. Creative ideas have occurred during shaving, walking, train rides, or reading material quite unrelated to the problem. Little, if any, of the evidence suggests that insight occurs during vigorous activity or during days when there is the pressure of many jobs and tight deadlines.

WHAT are some of the things that interfere with these essential conditions? What prevents fascination with a problem, for example? One interference is being pushed to solve a problem that doesn't concern us. When we are fascinated, we feel the problem pulling us. We do not feel pushed into it. The fascinating problem is one that we choose, one that somehow belongs to us. People do not need to be driven to do things that have an intrinsic attraction.

I do not believe that people can be pushed into being creative. Faced with a demand for a solution to a problem they have not chosen, people may come up with ideas. But I do not think that they reach their best creative thinking under such conditions. I believe that research administrators cannot develop a research program, then assign people to it, and get their best creative thinking. Certainly, some excellent research gets done that way. But most of the people involved see it as a job to be done rather than as a fascinating problem to be solved.

Another hindrance to fascination is the tendency to steer research people into the currently popular areas of investigation. An engineer may be fascinated by a problem which is not fashionable. He is detoured into another path because nobody else thinks the problem that fascinates him is very important. Closely related is the industrial requirement of saleability. You probably remember a very creative experiment in automobile design. It was the Chrysler "AirFlow." It was put on the market in the '30s, and it fell flat. One of the most creative body designs that had been developed was a commercial failure. That event teaches us that we had better not be fascinated by certain kinds of ideas. So, go back to working on ideas that are interesting, but not fascinating.

What are the blocks to saturation? Well, one of them is sheer lack of ability. Not everybody is equally able to learn and retain masses of information. Some people are more intelligent than others. Intelligence, by itself, is no guarantee of creativity, but it is certainly an asset. Another thing that interferes with saturation is time pressure. Often, we are under pressure to get results quickly. Then, we do not have time to absorb and become really familiar with background data. If we ask people to be creative and also to meet a deadline, we must be ready to accept less than their best.

Now let us look again at reorganization. What things interfere with this delicate process? One interference is what psychologists call "set." Let me introduce this by asking you to think of a runner facing down a track, crouched ready to go. When the gun goes off, he moves only one way. He is "set" for only one track. In contrast, a baseball outfielder is ready to move in many directions. Now, we can get set psychologically, too, so that we can move in only one direction. We are ready for only one of the possible outcomes. Here is an illustration, using a trick problem:

A streetcar begins its trip with one passenger. At the first stop, three people get on. At the next stop, four get on and two get off. At the next stop, three people get on and one gets off. At the next stop, five get on. At the next stop, two get on and four get off. Here is the problem: How many stops were there?

Most people regard this question as unfair. They have been adding and subtracting passengers. They did not count the number of stops because they thought the problem was to find the number of passengers. Our years in arithmatic classes have prepared us to look for certain facts rather than others. Consequently, we are not ready for a question about the stops. People listening to the streetcar problem impose limits upon themselves.

Here is the danger of specialization. We become so enamoured of certain approaches, certain hypotheses, certain beliefs about the type of answer that we cannot give them up. At this point, other people can help. Even though they are less familiar with the problem than we are, they may bring a fresh point of view. They may notice things we have overlooked. And these fresh ideas may come from a person who is completely untrained in our own field. That is why groups can be valuable in stimulating creative thinking.

THERE is another kind of constraint that can interfere with a free reorganization of the problem. This constraint is fear or anxiety. I do not mean the anxiety that makes us tremble but the kind that makes us cautious and hesitant. Sometimes, this anxiety is a fear of ridicule or disapproval. When people are anxious about appearing foolish in the eyes of others, they may keep excellent suggestions to themselves. It is this fact that led Osborn to his rule that, during brainstorming sessions, no evaluation nor criticism is permitted. The participants know that they will not be made to look foolish, and thus they can make farfetched suggestions.

It is pretty clear, however, that the rule against criticism does not really decrease all the anxiety. I participated in one brainstorming session where the topic was "How can we improve our organization?" One of my first thoughts was: "Get rid of the president!" I did not announce this thought during the brainstorming session. The president was in the room. You see, the rule did not really

eliminate my anxiety about the social consequences of my suggestion.

In arduous and lengthy problems, the anxiety about social ridicule cannot be decreased by arbitrary rules. People on a research team must somehow learn not to be afraid of one another's criticism. It is essential to creative team activity that people express their disagreement. The solution is not to eliminate conflict artificially, but to help people see that criticism of their ideas does not mean a personal rejection. In other words, for creative teamwork, people need to learn how to work together without suppressing parts of themselves. This accomplishment is not an easy one, but today psychologists know more about helping people reach it than ever before.

Anxiety about social disapproval not only prevents people from making suggestions; it can even prevent them from thinking of new suggestions. It actually seems to interfere with free-ranging, flexible thinking. The anxious person is so concerned about his relationships with other people that he cannot give full energy to the problem.

ANOTHER anxiety can block creative thinking. It is the anxiety that arises from the chance of decreasing our own self-esteem. We do not dare to let ourselves think some thoughts because we regard them as bad. If we think bad thoughts, we believe, we are bad people. Now, in the playful, free-moving process of letting our ideas spontaneously reorganize, there is no telling what kinds of thoughts may occur. It is possible, even in a machine design problem, for stray images of a hostile or sexual nature to occur. If we must be constantly on the alert to suppress such thoughts, we may interfere with the freedom of the reorganizing process.

You may test this for yourself by trying to visualize an aggressive situation. Imagine slapping the face of one of your friends. Do you notice any difficulties in getting clear images of this action? Many people can imagine raising their hand but cannot imagine the actual slap. Why do we resist such thoughts? It is not that they are so strange. Actually, we do not want to admit, even to ourselves, that we could think such things. And yet, thinking is not the same as doing. The imagination has no serious consequences. Your friend will never feel the mightiest blow delivered within the confines of your own imagination. Highly creative people can probably let their imaginations rove freely without anxiety. They dare to take the risk of spontaneous thinking. Perhaps, then, one's own personal security and ability to accept himself as human may help him reach his maximum level of creative thought.

NOW, let us look at a few of the practical implications of this analysis of creative thinking. First, we must start with bright, well-trained people. Second, we need to give them ample opportunity for stimulating one another. We need to encourage discussion and interaction so as to permit both saturation and the breaking of directional habits of thinking. This suggests a third item: the need for developing a warm and understanding atmosphere in the human relationships that surround creative people. True, there is some evidence that many creative scientists tend to be solitary, even somewhat cantankerous people. But that does not mean that they do not require understanding. Part of the atmosphere they need is an acceptance of their desire to be alone. They need contact with people, too. We cannot, however, expect them to be very skillful in human relationships. That simply means that administrators and supervisors, whose job is human relations, must take a large share of the load.

A fourth thing that would probably help creativity is to provide opportunities for "playing around." Playing with things for their own sake, twiddling dials, and fiddling with knobs may well result in new illumination and new understanding of a problem. Then, finally, there should be opportunity to get away from the problem after a period of intensive saturation. We should become more realistic about the eight-hour day requirement. In most organizations, it is praiseworthy to stay in your office even if you are not productive. At the very least, this attitude needs to be re-examined. At best, it could be eliminated.

SO FAR, I have spoken mostly about the individual and the creative process, but I have a few things to say about the role of the organization in creativity. Obviously, if a company does not really value creativity, there is not much point in doing anything about it. We can tell something about the value that a company places on creative thinking by asking a few questions. What happens to the off-beat thinker? Is the company willing to take the financial risk of letting people develop really creative ideas—ideas that may not result in profit this year or next? It has been estimated that the time between the inception of an idea and its commercial utilization is at least twenty years. That is a long-range and risky investment, and certainly some companies ought to have no part in it. I am not talking about gadgeteering. It is not too hard to find people who will do a good job of making new gadgets and who will work at it eight hours a day. And that is what a company must have if it wants products.

Top management must seriously ask itself whether it values products or creativity. A company is not bad if it says it wants products. And there is nothing wrong with saying that we cannot take the risk that is required to develop truly creative people in our organization. But a management ought not deceive itself by saying that it wants

people to be creative and then put them to work on products on an eight-hour basis. Fundamental research, letting people follow the paths that fascinate them, playing around with ideas—these things may some day result in real profits. But it is a long and risky road. Before executives climb on the bandwagon of creativity, they should look again at the lives of really creative people. And they had better be prepared to find heartbreak, financial insecurity—and popularity that came too late.

FOR a moment, let us stop looking at those who do the creating, and look instead at those who evaluate the products of the creators. I wonder what kind of people are on the committees that sit in judgement. And I would like to raise this question: How creative, how daring, do these people need to be if they are to make full use of creative scientists and designers? A committee that is made up of cautious, conforming people may have some real difficulties in evaluting the curious thoughts of curious people. Hiring creative people and giving them favorable conditions for their work are not likely to do much good if the evaluation committee lacks the sparkle of a playful imagination.

I will close by telling you my favorite story about this matter. The details were given in the *New Yorker* magazine some eight or ten months ago. That article contained a delightful series of letters between two unusual correspondents. One of the writers was an executive of the Ford Motor Co., and the other was an American poetess. The executive was charged with responsibility of finding a name for a new car that the company was planning to introduce. With praiseworthy insight, the executive decided to seek the help of the poetess in finding a suitable name. The suggestions offered to the company ranged considerably in value—a not unexpected turn of events with creative people. On one occasion, she rose to the heights of suggesting "Astronaut." At other times, her imagination sank so low as to suggest *"Andante con moto."* On the whole, however, the suggestions were stimulating and valuable. As all of you know by now, none of the names suggested by the poetess was used. Apparently, a creative and poetic mind was not wanted for this job. The name finally chosen by someone who dwells deep within that great organization was "Edsel."

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and *Machine Design*.

Tips and Techniques

Solving Cubic Equations

Many cases arise in engineering problems where the calculations result in an equation in which the unknown quantity appears in functions of the second and third powers. An example is the case of a shaft under bending and twisting moments, where the equivalent stress is a function of the cube of the shaft diameter. The resulting equation can be solved by

1. Cardan's solution.
2. Substituting values for the shaft diameter in the equation, plotting the results, and arriving at a value which satisfies the equation.
3. By successive approximation.

The third method can be used, aided only by a slide rule to obtain a satisfactory result. For example, an equation is left such as $90{,}000D^3 - 7{,}600D^2 - 22{,}400 = 0$. Divide throughout by the coefficient of D^3 and collect all terms other than D^3 on the right hand side. Thus, $D^3 = 0.0844D^2 + 0.249$.

First Approximation: Discard the term D^2. Then, $D^3 = 0.249$ and, by slide rule, $D = 0.63$.

Second Approximation: Substitute $D = 0.63$ in the discarded term containing D^2. Thus, $D^3 = (0.0844 \times 0.63^2) + 0.249 = 0.0334 + 0.249 = 0.2824$. Therefore, $D = 0.656$

Third Approximation: Substitute in the D^2 term, the value of 0.656. Then $D^3 = (0.0844 \times 0.656^2) + 0.249$, and $D = 0.660$.

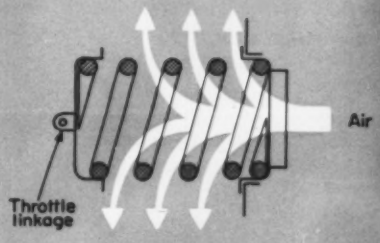
This shows little change from the second approximation and is approaching the correct answer. If desired, another approximation will yield a more accurate result.—ALEX B. CARR, *lecturer in machine design, Ryerson Institute of Technology, Toronto, Ont.*

Prevent Paper Wrinkling

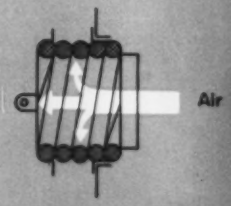
It is easy to prevent drawings from wrinkling due to changes in humidity and the weight of the drafting paper. Simply release the fasteners on each side and the bottom every evening and refasten again in the morning. The paper will stretch evenly and remain unwrinkled.—C. J. MILAN and A. D. ANDERTON, *design engineers, Oil Well Supply, Garland, Tex.*

scanning the field for *ideas*

Compression - spring valve offers a simple, effective approach to control of high-velocity air flow. Developed by Connor Engineering Corp. for use in a high-pressure air diffuser, the valve is simply a helical spring covered with neoprene tubing. One end of the spring fits into the air-supply duct and the other end is capped. Air temperature and volume controls are mechanically linked to the cap. Air passes from the duct into the chamber by passing through the spaces between the spring coils. When the control mechanism compresses the spring, air flow is throttled or entirely shut off.



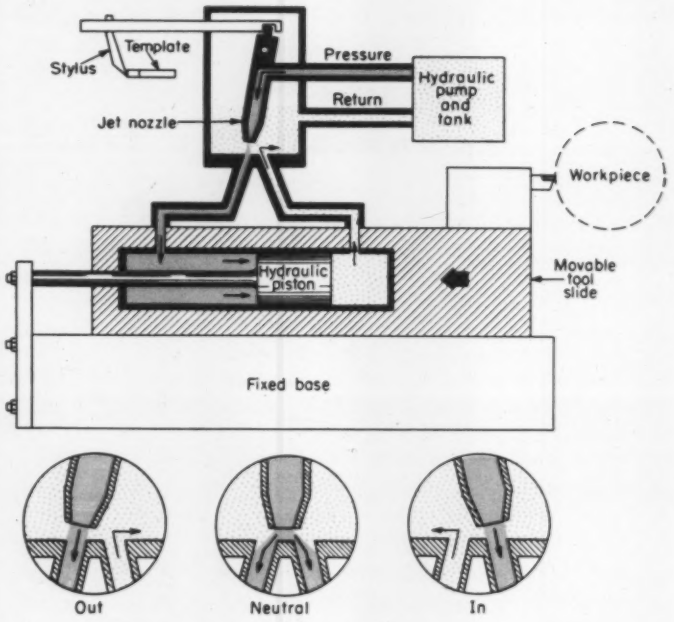
Open

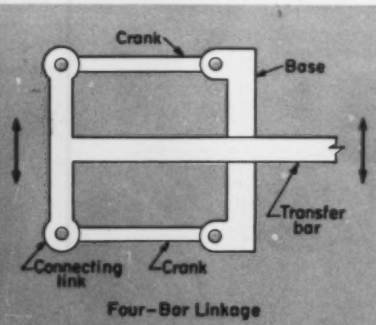


Closed

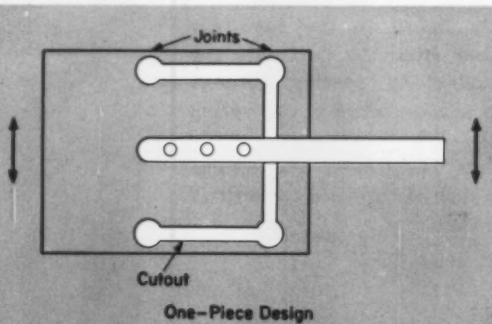
Swinging hydraulic jet serves as a two-way valve to control double-acting cylinder output in response to mechanical input signals. The design, developed by Gisholt Machine Co., is utilized in a lathe tracer unit. A tracer follower is mechanically linked with the jet nozzle, which directs oil under pressure through two openings which lead to opposite ends of the cylinder.

When the jet nozzle is in neutral, oil is delivered at equal pressure to both ends of the hydraulic piston, which is fixed. As the tracer stylus moves along the template, pressure balance is shifted from one end of the piston to the other by the swinging jet, causing the cylinder, tracer slide, and tool to move in or out and generate the desired contour.



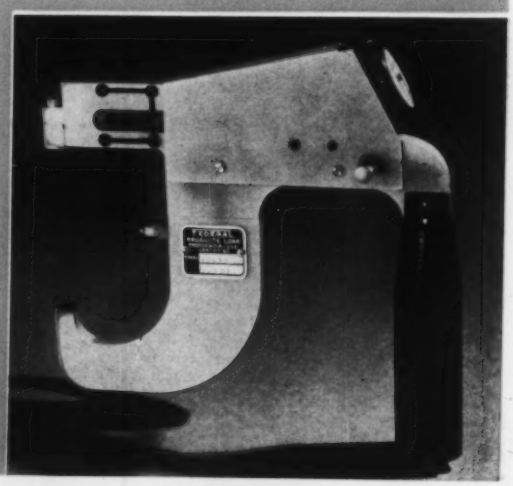


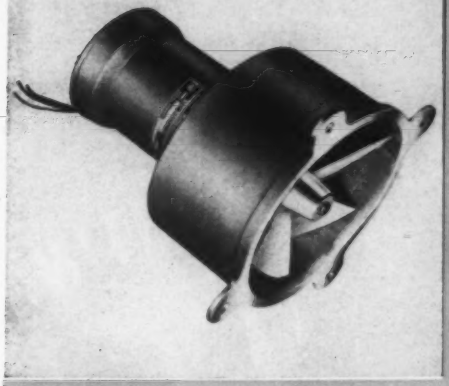
Four-Bar Linkage

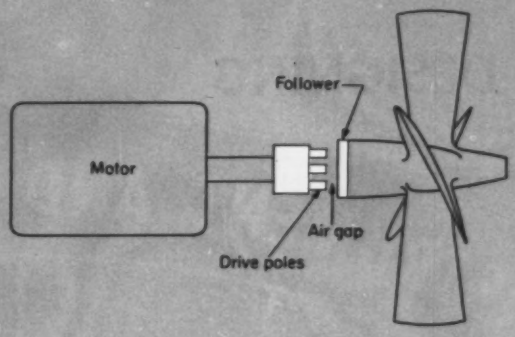


One-Piece Design

One-piece "four-bar linkage" simplifies production problems and eliminates wear between moving parts in a limited-motion mechanism. The design was developed by Federal Products Corp. for employment in a high-precision inspection gage. The linkage consists of a solid block with a rectangular area in the center cut free on three sides. "Pivot" points at the link junctions are produced by thinning the wall with holes. In use, the connecting link is deflected vertically, and the "cranks" radially, as work is measured. The base link remains stationary as a reference point. Movement of the connecting link is transferred to a dial indicator by a bar mounted rigidly on that link.



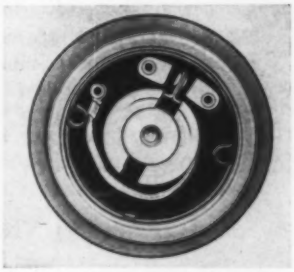


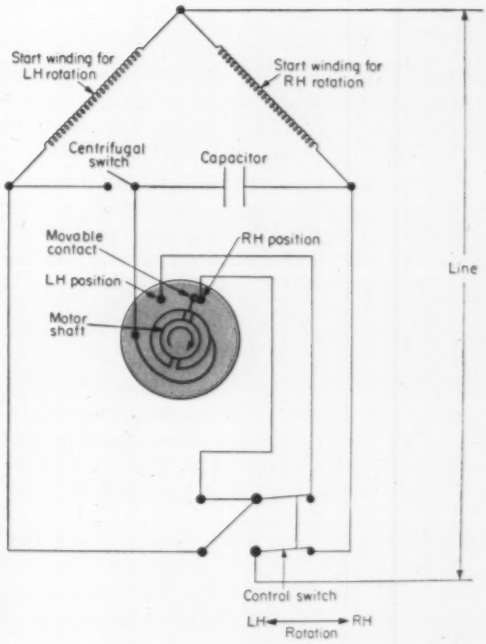


Demand control of blower speed in response to pressure changes is provided by a magnetic drive coupling. Designed by Eastern Industries Inc. for use in an airborne blower application, the coupling consists of a permanent magnet which is mounted on the motor shaft and has a series of poles protruding axially. These poles are separated by an air gap from a washer-shaped follower that is attached to the fan blade. Rotation of the magnet induces rotation in the washer follower and fan blade. At sea level the speed of the fan is approximately ⅓ the motor speed. As the drag on the fan blade is reduced with altitude or decreasing air density, the blower speed increases.

Rapid reversal of single-phase, ac motors is accomplished by a built-in, presetting switch design. Developed by Franklin Electric Co. Inc., the device minimizes the time delay associated with conventional motor-reversal methods. Positive, preset contacting motion is provided by a pair of nylon friction shoes, carrying a double-faced contact, and fitted to the motor shaft.

With the motor turning, friction between the motor shaft and the nylon shoes causes the contact to rotate until it closes a circuit. Under this condition, the motor continues to operate as a normal capacitor-start induction motor. Reversal of motor rotation occurs when the control switch is thrown to the opposite position. The reversing mechanism has already provided a closed circuit to connect the capacitor in series with the starting winding.

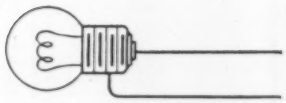




DESIGNING INSTRUMENT AND PANEL LIGHTING

By **RICHARD COBURN**
Head, Man-Machine Section
U. S. Navy Electronics Laboratory
San Diego, Calif.

. . . to provide maximum visibility and visual comfort for the operator. Design details are given for ten different methods of lighting. Suggested areas of application of each technique are discussed based on the lighting environment.



PROPER illumination is one of many important factors a designer must carefully consider to assure effective functioning and use of equipment, machines, and instruments. At first thought, it might appear that instrument and panel illumination is a minor design problem. In some applications, however, attaining satisfactory illumination may pose real difficulties and may appreciably increase design costs. Also, if adequate illumination is not provided, even equipment with otherwise outstanding design features may become troublesome or unsafe to operate.

Conditions of Illumination

There are three broad conditions of illumination in which man-operated machines, instruments, and equipment must function. First there is the high and fairly constant ambient level of illumination provided by daylight, or bright artificial light, or a combination of both. Under this condition of illumination, there is ample light to read function labels and displays and to determine control settings. The designer need not concern himself with illumination except as may be especially required for attention-getting value.

A second condition is the low and fairly constant ambient level which may be utilized for special purposes. This kind of illumination environment is typical of radar operating spaces, for example, where it is desired to maintain partial dark adaptation so that the operators may detect faint signals on the radar screens. In this environment everything which the operator reads or otherwise must see to manipulate requires illumination.

The third condition of illumination is a widely varying ambient level. As an example, equipment installed in an airport control tower is subjected to a tremendous range in illumination, from peak daylight levels to dim-out night levels. These conditions impose the greatest burden on the designer if his equipment is to be equally operable under daylight, dark, and transition levels. As in the low ambient condition, everything which the operator needs to read or see to manipulate must be specially illuminated. More than that, though, this special illumination must not be too bright at the lowest ambient level nor too dim at transition levels. To satisfy such requirements the provided illumination may need to be controllable over a wide range.

Factors Affecting Visibility

The problem of providing special illumination might be fairly easy if illumination were the only factor affecting visibility. Actually, however, illumination is only one of a number of factors which

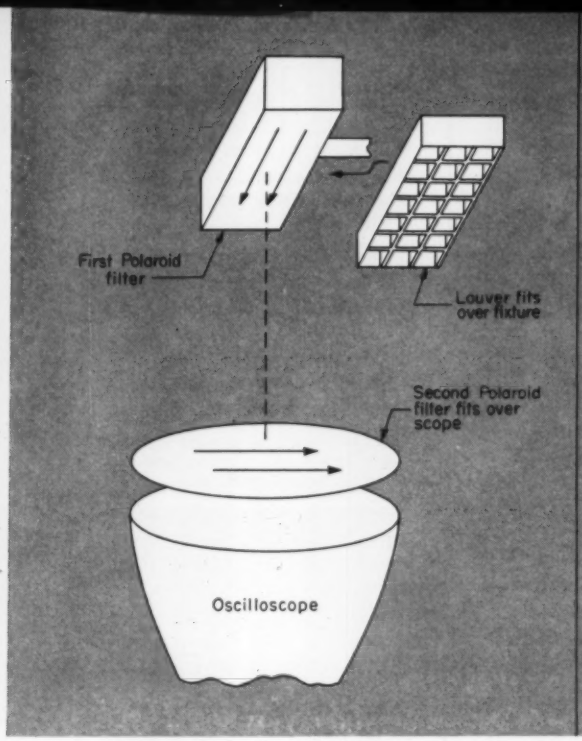


Fig. 1—Elements of a cross-polarized lighting system. The light source is a floodlight covered with a Polaroid filter. A second filter, polarized at right angles to first, is positioned over the oscilloscope to cancel out incident light. The lighting fixture louver prevents spreading of the light and minimizes glare.

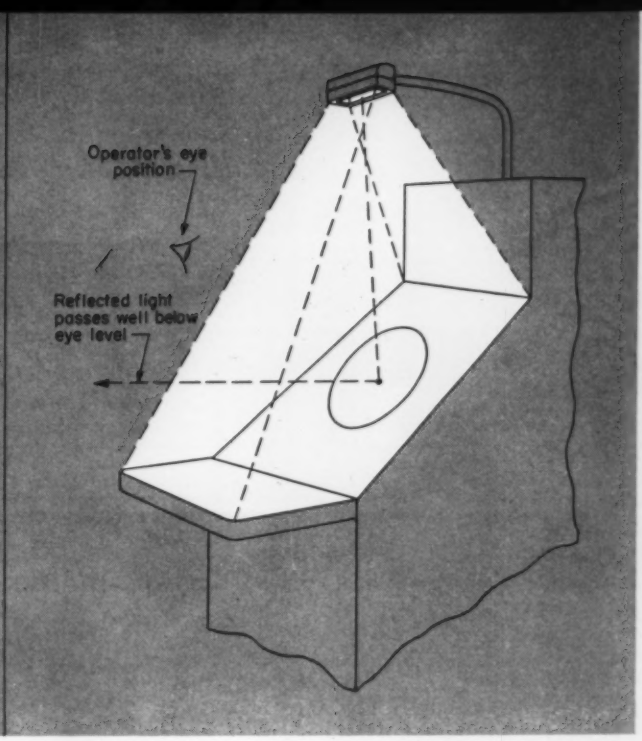


Fig. 2—Installation arrangement of polarized lighting applied to a radar indicator using lighting elements in Fig. 1.

determine the operator's ability to see his work. Other factors include: 1. Legibility of labels and symbols. 2. Contrast of figures against their backgrounds. 3. Reflections and glare. 4. Color contrast. It may be pointed out, for example, that 30 foot-candles of light falling on a gray figure or object against a darker gray background may not be nearly as effective as 10 foot-candles falling on a white figure against a black background.

By maximizing some of the other factors which contribute to visibility, the amount of illumination required may be reduced. Numerals and letters should be of simple style with a stroke width about one-eighth the letter height, rather than of complex styles or exceedingly thick or thin stroke widths. Contrast should be made high. White numerals or symbols against black backgrounds (or the inverse) should ordinarily be used instead of white on gray or a light color. In most applications, reflections and glare are unwanted, and in eliminating them visibility may be substantially improved without increasing the illumination level. Of course, there are some special situations where specular reflections may be desired, as for example, to see cross-hairs against a dark background.

For good visibility of the work, each factor of importance should be given proper consideration in design. It is far better to enhance visibility by maximizing figure-to-background contrast and/or selecting legible lettering than to attempt to gain the same level of visibility merely by raising illumination levels.

Panel Lighting

Direct illumination is the oldest form of illumination for workspaces. Because of its disadvantages of glare, reflections, and nonuniformity, however, it has been largely supplanted as a method for illuminating panels by other techniques. Nevertheless, there are still some applications best satisfied with direct illumination.

Cross-Polarized Lighting: A special direct-illumination technique was recently developed by the Navy Electronics Laboratory for illumination of radar indicators.* This technique is termed cross-polarized lighting, Fig. 1. The light source consists of a small floodlight equipped with a Polaroid filter; and a second Polaroid filter is fitted over the scope and crossed with respect to the first filter. This arrangement allows a moderate amount of polarized light to fall on the operating panel of the indicator, but the second filter prevents this light from reaching the oscilloscope face, thereby

*C. T. White—"The Use of Polarized Light for the Illumination of Radar and Sonar Spaces," *U. S. Navy Electronics Laboratory Report* 669, unclassified.

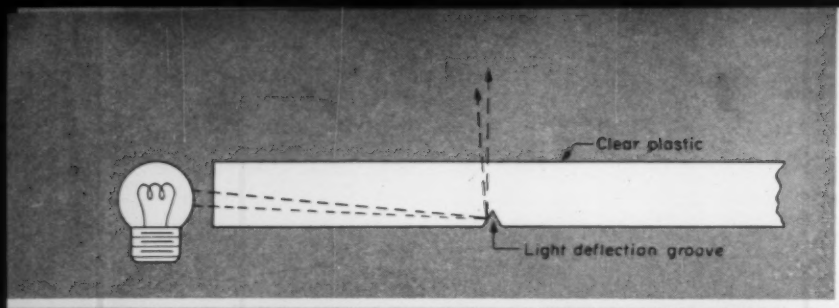


Fig. 3—Arrangement for edge lighting a back-engraved acrylic-plastic panel.

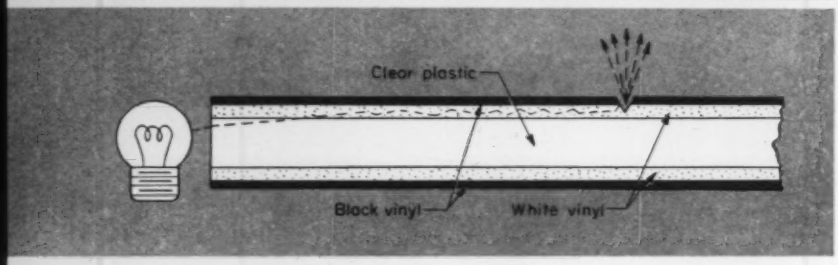


Fig. 4—A method of edge lighting laminated plastic panels used in aircraft cockpits.

maintaining maximum contrast on the display.

Advantages of such a technique are: 1. It is inexpensive. 2. It eliminates the requirement for costly individual illumination of controls and displays on the panel. 3. It reduces visual fatigue by bringing up the brightness of the panel surrounding the oscilloscope. Care must be taken in designing and installing cross-polarized lighting systems to avoid: 1. Glare from the lamp fixture itself. 2. Reflections of the lamp in the scope filter. 3. Reflection of the operator or his clothing in the oscilloscope filter. One suggested installation arrangement is illustrated in Fig. 2.

Selective Spectrum Lighting: Other specialized direct lighting techniques have been employed in recent years. Some of these have been of the selective-spectrum variety. One noteworthy example is the broad-band blue system used in the Air Force's SAGE centers. The principle behind selective spectrum lighting is somewhat similar to that for cross-polarized lighting. That is, light which emanates from a specially filtered fixture may be used for workspace illumination, but it is excluded from radar oscilloscopes by means of a complementary oscilloscope filter. In broad-band blue, the filter over the fixture eliminates all but the blue end of the spectrum, and the scope filter absorbs the blue to prevent this light from falling on the scope screen. Light from the oscilloscope phosphor (yellow or orange) may be readily seen by an observer since it passes through the scope filter without absorption. Selective spectrum systems have the disadvantage of distorting surface colors and lessening color discriminability.

Edge Lighting: The versatile technique of edge lighting is extensively used in various forms to provide clear and uniform illumination of instruments and panels. Fig. 3 shows an arrangement for edge lighting a back-engraved acrylic plastic panel. Light is confined within the plastic as long as it strikes the surface at an angle less than the critical angle, which is about 43 deg in air. However, if the light strikes any surface at an angle greater than this, it passes through that surface. To direct light out to the eye of an observer it is customary to engrave the back side—the side away from the observer. Front engraving is not nearly as effective because only a relatively small amount of light escapes on the engraved side, whereas the engravings direct considerably more light out the opposite side.

Fig. 4 illustrates a lighting technique now extensively used in aircraft cockpit panels. The panel is fabricated as a lamination consisting of five layers. The center is a thick sheet of transparent acrylic plastic. On both sides of this layer is a sheet of white translucent vinyl. On top of the white vinyl is a thin sheet of tough black opaque vinyl.

Light readily enters the translucent vinyl from the plastic because the critical angle for the plastic-vinyl boundary is very small. Thus, light is well distributed and diffused throughout the translucent vinyl. Figures may then be engraved through the outer layer of black vinyl. Since this allows emission of light in all directions, the engraved lines are clearly illuminated. Other techniques can be used to cut away the black vinyl, but the end results are similar.

Panels of all sizes, even including rotating dials, may be illuminated this way. In the design of panels of this type used in aircraft, the lamps are surrounded by a red filter so that only red light may reach the eyes of the dark-adapted operator. Laminated edge-lit panels of this sort have many advantages, such as uniformity of illumination, elimination of stray light, high contrast, ruggedness, and elimination of glare and specular reflection.

Back Lighting: With translucent materials, back lighting may be employed. Black letters on white may be obtained by stamping, printing, or use of a stencil or mask on a diffusing layer. Or, for

white letters on black, the diffusing layer may be covered with an opaque layer for engraving. One of the disadvantages of back lighting is the difficulty in attaining a sufficiently uniform level of illumination at all points on the panel. For this reason, back lighting is best employed only for illumination of small display surfaces.

Electroluminescent Lighting: One of the promising newer techniques which might be applied for back lighting is electroluminescent lighting. Electroluminescent panels are special laminations which are, in effect, capacitors with electroluminescent materials distributed through the dielectric medium, and with the whole lamination translucent. When appropriate voltages are applied to the "plates," the electroluminescent material glows, providing a uniform but low-level area illumination. As brighter electroluminescent panels become available, they will be well suited to back lighting applications utilizing black figures against bright backgrounds.

Instrument Lighting

Illumination of number counters often poses special lighting problems. Ordinarily it is not desirable to recess the counter deeply; with a counter assembly mounted close to the panel surface, it is difficult to illuminate it.

"Piped" Lighting: One technique which has been used with good results is piping the light to the display portion of the counter with an acrylic plastic duct, Fig. 5. Note that the beveled surface of the duct is roughened to diffuse the light in all directions. If a smooth bevel of this slope were used, it would tend to bend the light up and away from the counter, since light bends away from the surface normal as it passes from a dense optical medium to one of lesser density.

Light ducting can also be used for illumination of panel-mounted meters without modification of the dial face. One such arrangement is illustrated in Fig. 6.

Switch and Dial Lighting: Illumination of a rotating dial within a fixed dial may be accomplished by fabricating both of them of clear plastic and using the outer dial as a light duct for the inner dial, Fig. 7. This design gives a parallax-free display if the back side of each dial is engraved.

There are special requirements in illuminating

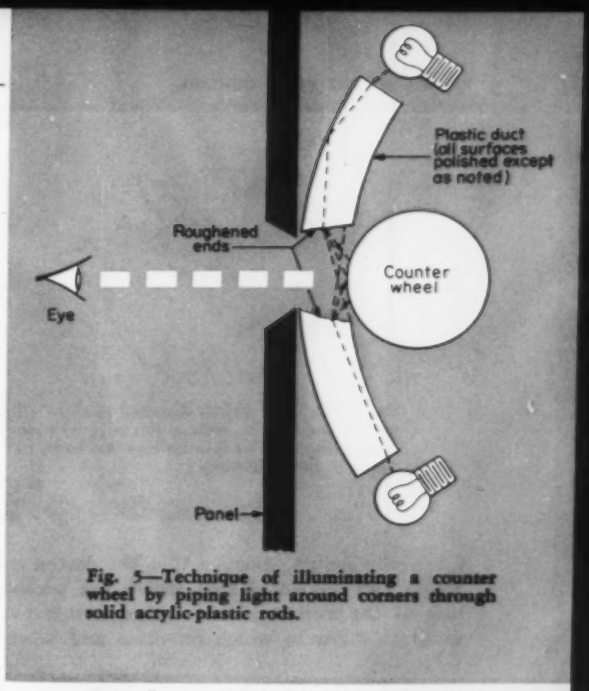


Fig. 5—Technique of illuminating a counter wheel by piping light around corners through solid acrylic-plastic rods.

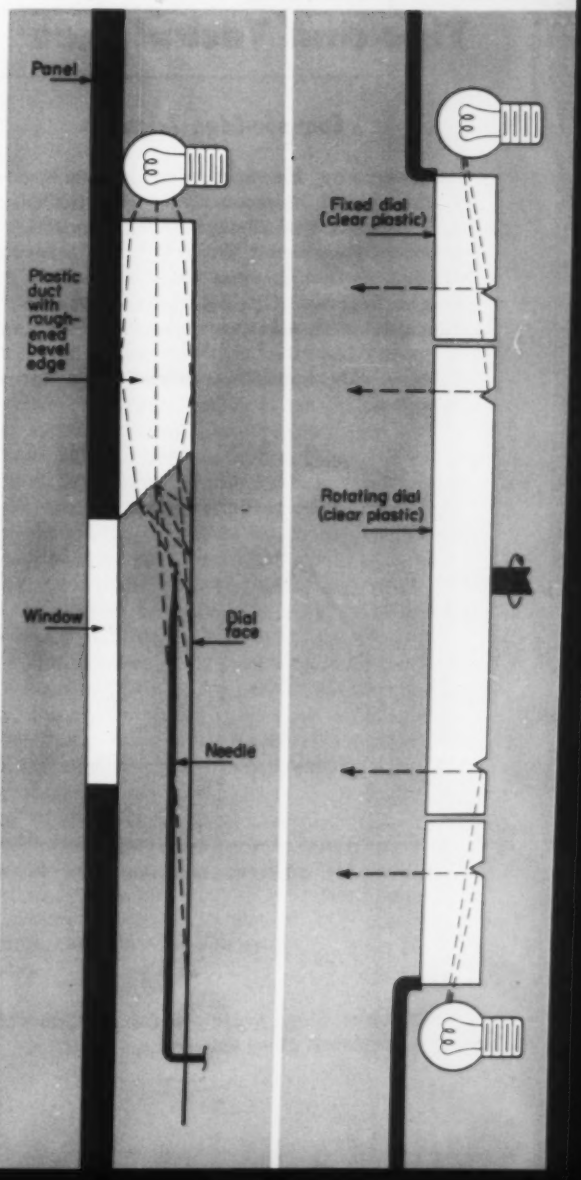


Fig. 6—Meter dial-face lighting with plastic duct. Beveled edge is roughened and produces a circle of light around the dial face.

Fig. 7—Method of lighting concentric clear-plastic dials. Engraved lines or grooves cut in the back of each dial deflect light toward the operator.

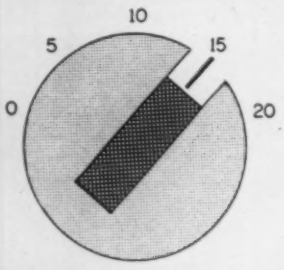


Fig. 8—Selector switch designed to show all switch positions as well as the selected position. Illumination is from ambient light, or edge or back lighting.

a selector switch. Assume that the design requirements call for being able to see the present setting of the switch plus all other switch positions so as to know in which direction and how far to rotate the switch. These requirements can be met with the arrangement in Fig. 8. A fixed dial with numerals and long indices representing each of the various switch positions is engraved in plastic or on a laminated panel as described previously. The switch knob is fitted with a round skirt of opaque material. A notch is cut in the skirt allowing one, and only one, index line to show through. Such a technique is equally satisfactory under light or dark ambient conditions.

Design Summary

Whatever lighting system the designer develops, he should remember to: 1. Make illumination an integral part of the original design plans—not an afterthought. 2. Select the illumination technique best adapted to his particular application. 3. Minimize glare and reflections. 4. Provide the right amount of illumination. 5. In all ways, make the operator's visual task comfortable and free of strain.

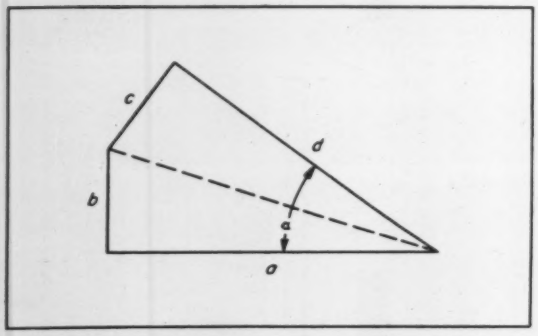
Tips and Techniques

Common-Edge Triangles

Occasionally in sheet-metal layout, gear-train design, etc., it is necessary to find the combined apex angle of two 90-degree triangles that have a common hypotenuse. There are two forms for the solution, depending upon which side of the second triangle is given. The equations are in a form that is adaptable to solution on most calculators.

Given side opposite common apex in second triangle:

$$\text{Sin } \alpha = \frac{b\sqrt{a^2 + b^2 - c^2} + ac}{a^2 + b^2}$$



Given side adjacent common apex in second triangle:

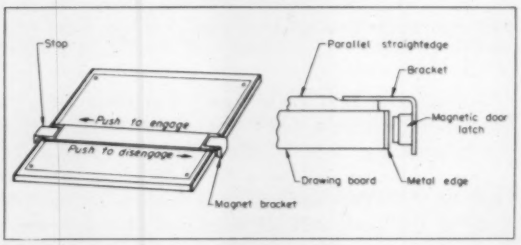
$$\text{Sin } \alpha = \frac{a\sqrt{a^2 + b^2 + d^2} + bd}{a^2 + b^2}$$

Example: Steps are given for solution of angle on a calculator, given a, b, and c.

1. Multiply $a \times a$ and add $b \times b$ to it.
2. Make a note of this figure, as it is used again in Step 7.
3. Subtract $c \times c$ from result of Step 1.
4. Extract square root of result in Step 3.
5. Multiply square root from Step 4 by b.
6. Retain result of Step 5 and add $a \times c$ to it.
7. Divide result of Step 6 by $a^2 + b^2$ from Step 1.
8. The result is the sine of angle α.

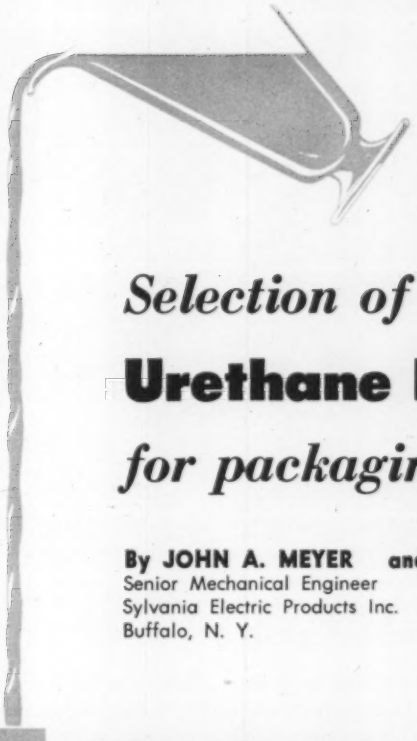
—C. S. JACKSON, *supervisor of design drafting, Burroughs Corp., Plymouth Div., Plymouth, Mich.*

Straightedge Stop



Holding a standard, parallel straightedge from sliding on a metal-edged, adjustable drawing board at angles of 30 degrees or greater can be accomplished inexpensively. Merely attach an ordinary cabinet-door magnetic latch to a small bracket, as in the sketch.—DONALD R. GODFREY, *Westinghouse Electric Corp., Sharon, Pa.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.



Selection of
Urethane Plastic Foams
for packaging electronic equipment

By JOHN A. MEYER and **HAROLD SHAPIRO**
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Sylvania Electric Products Inc.
Buffalo, N. Y.

Urethane plastic foams, in a variety of densities, offer design possibilities in applications requiring vibration protection, thermal insulation, or structural rigidity without excessive weight. Because of the relative newness of the urethane foams, their producibility aspects and techniques of formulation and molding are presented here to acquaint designers with the criteria governing foam specifications

PRESENT-DAY military requirements emphasize the importance of reliable operation of electronic equipment under severe environmental temperature conditions. This requirement has focused attention on problems of cooling systems and their relative weights.

Heat-dissipation methods range from natural convection and radiation to specially designed cold-plate chassis. However, where ambient temperature is higher than that of the equipment, as in supersonic aircraft with high skin temperatures, thermal insulation is required to reduce heat transfer from environment to equipment.

Urethane combines more required properties than any other plastic foam available for thermal insulation of electronic equipment. For this reason, urethane was selected by Sylvania for application in Hustler equipment. For example, a technique of direct cooling by air was developed in which electronic equipment is shielded by a urethane foam blank, Fig. 1.

In addition to being lightweight, urethane has low thermal conductivity, high heat-distortion temperature, and relatively high strength. Its availability in a variety of densities makes it not only an excellent thermal insulator but a structural potting material which protects packaged equipment from vibration and shock, Fig. 2.

Methods for using urethane foam for thermal insulation and vibration damping purposes include foam-in-place applications in which the structural properties of urethane are utilized, and the potting technique in which components are packaged for protection against vibration. In both these methods, a liquid mixture of urethane is poured into a cavity and allowed to expand to fill it completely. In foam-in-place applications for structural rigidity, the cavity of a hollow part is filled with urethane which expands to become the permanent core of the assembly. When used as a lightweight potting material, the urethane is poured into a mold to expand around a component. The component, with its foam "jacket," is removed from the mold and used as a single unit in an assembly. A third and alternate method of using urethane foam requires cutting or machining preformed foam blocks or slabs to shape before fitting them into place.

Types of Plastic Foam: Urethane foam, also known as isocyanate foam, polyester foam, or

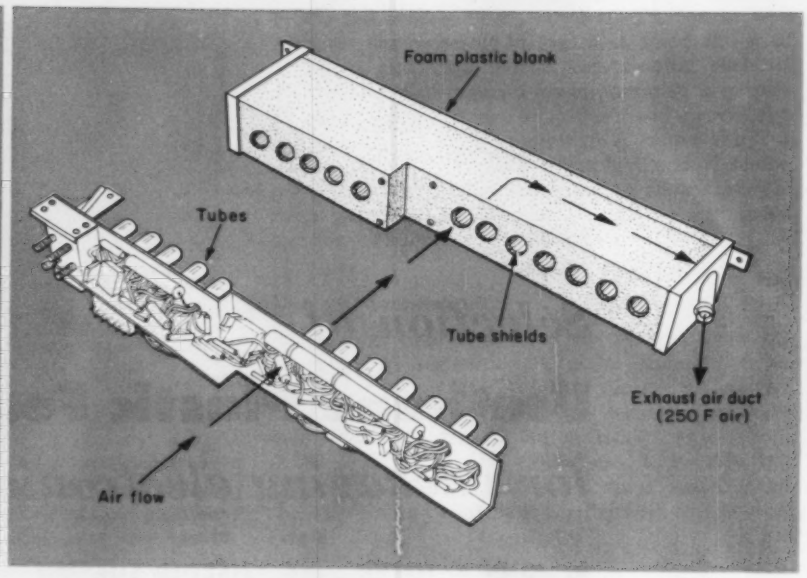


Fig. 1—Direct cooling by air of electronic equipment shielded by urethane foam. Passages between embedded flexible tube shields and tubes, formed when the foam blank and chassis are assembled, provide for circulation of the coolant. Low heat loss factor of urethane confines the major portion of the heat to the cooling-air stream which often attains temperatures in excess of 250 F.

polyester-urethane, combines more required properties for thermal insulation of electronic equipment than the vinyls, styrenes, phenolics, epoxies, or acetates. Some types of urethanes can be formulated to produce a soft, flexible foam, and other types can be made hard and rigid. They can also be adapted to laboratory scale work and to high-speed production runs.

Three formulations of urethane are used extensively for packaging applications:

1. A foam with a density of 7 lb per cu ft is generally used for component packaging. This formulation exhibits the most favorable combination of mechanical, electrical, and chemical properties. It also has a low thermal conductivity, high-temperature stability, and a relatively long mixing time during preparation.
2. A 10 lb per cu ft formulation, which combines ultimate structural properties with a relatively low density, is used in applications where the 7 lb per cu ft foam does not meet strength requirements.
3. A highly reactive 7 lb per cu ft foam is used where violent foaming and resultant high pressures are needed to fill intricate mold voids. Because of the difficulty in controlling this foam, it has often been found necessary to adjust mold design before satisfactory packaging is obtained.

All of the urethane formulations can be colored for identification purposes. However, urethanes tend to discolor with age. It is standard practice to include flame retardants in all foam formulations.

Mold Design: The purpose of the mold is to restrict the foam package to the required shape. Since high pressures are generated during foaming, mold materials must be of sufficient strength to resist these pressures. Aluminum plate, ¼ in. thick, has been used satisfactorily, Fig. 3.

Openings in the mold should include small riser holes through which gases and excess foam escape, and a pour hole for pouring or injecting the foam batter. Proper riser design is necessary to produce a foam package of the required density. Restricting the escape of foam, or permitting an excess to escape, results in a package of higher or lower density than originally calculated.

Mold volume must be accurately determined so that the correct amount of raw materials needed to yield proper foam density can be calculated. The most important part of the calculation is specifying the excess of raw materials necessary to help generate exothermic heat which creates sufficient pressure to force the foam in and around intricately-shaped parts. This excess ranges from 5 to 200 per cent depending on the size and design features of the mold.

Wherever possible, molds should be designed for single-pour applications. Multiple pours should be avoided because of foam-to-foam adhesion problems. When necessary, foam parts may be bonded with epoxy adhesives. However, parts require contact pressure during cure to form a good bond. Fig. 4 shows a foam blank with exhaust chamber molded in place rather than separately.

Foam-Density Control: Foaming is caused by a dispersion of gas throughout the resin to increase volume while maintaining weight. By means of special formulation and controls, volume can be increased from 2 to 250 times, which indicates the potential of the variety of densities that can be obtained. Reaction of the gas (carbon dioxide in the urethanes), determines whether foam cells will be unicellular or interconnecting. Many end properties depend upon cell type. The rigid closed-

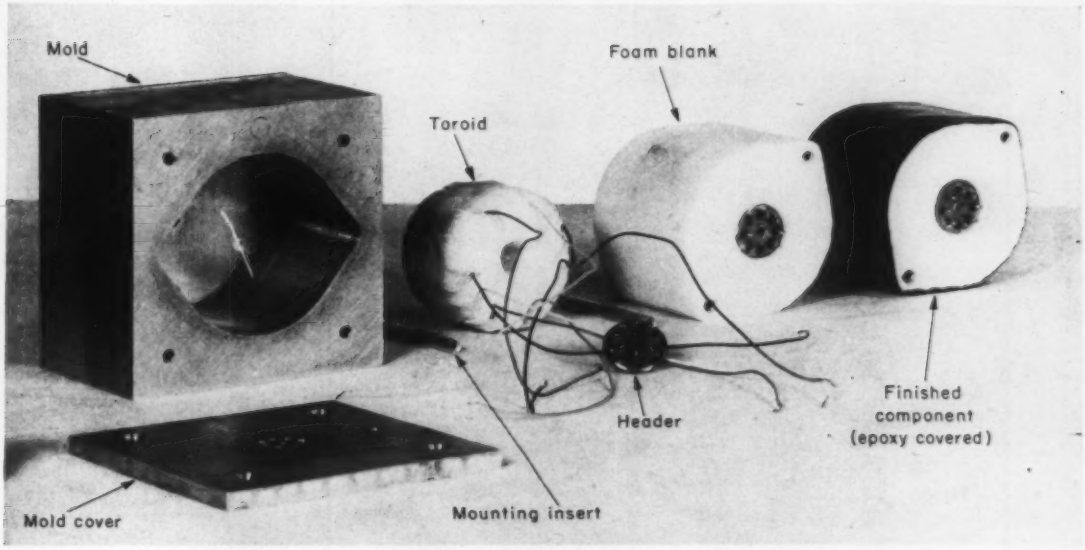


Fig. 2—Urethane foam used as a lightweight potting material. Insulating properties of foam do not affect operating temperature of the toroid since power dissipation is very low. Foam packaging affords maximum protection from vibration which may vary from 5 to 500 cps at high loads. Strength of the blank is directly proportional to the square of the cross-sectional height. Rugged mold design is indicative of foam pressure generated.

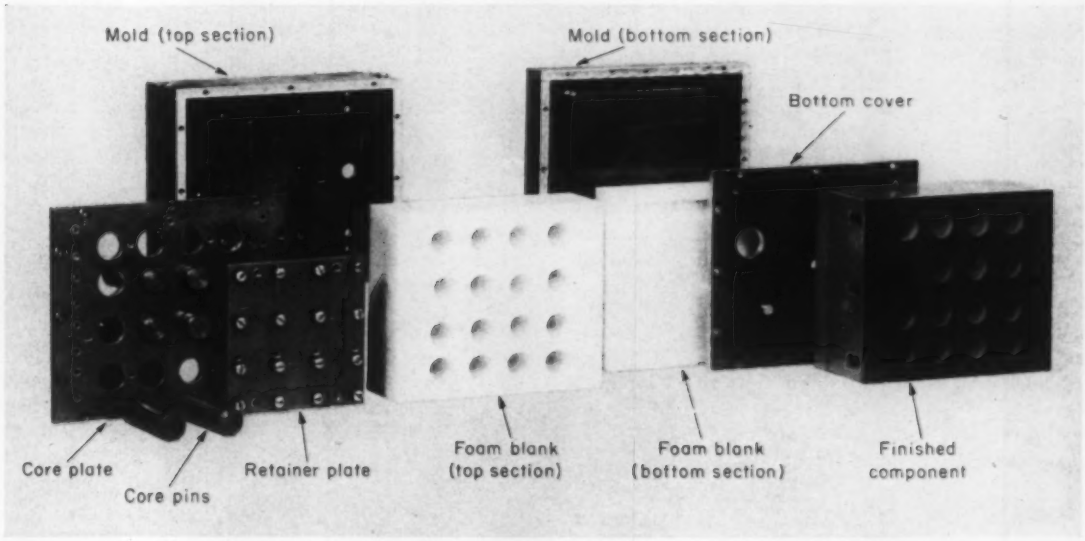


Fig. 3—Air-cooled tube blank, top section, and exhaust chamber, bottom section. When necessary, foam sections are bonded with epoxy adhesives to form single units. Mold sections, covers, and retainer plates are of thick aluminum to resist foam pressures and to retain dimensional accuracy of finished blanks.

cell type of urethane has the most desirable properties for lightweight packaging.

Foam density can be varied from 2 to 30 lb per cu ft. Properly controlled formulations yield densities which can be controlled and reproduced to within ±20 gr per cu ft in batches over 2 lb. Closer control is possible in smaller batches. Batch sizes currently used for packaging electronic units are well under 1 lb. Every component used in the formulation is a variable which affects the end product. Therefore, formulations must be completely evaluated and controlled so that results will be consistent and reproducible.

Mold Preparation: Prior to pouring, the mold must be thoroughly degreased and the inner surfaces wiped with acetone. Surfaces not requiring foam adhesion are then coated with a thin film of

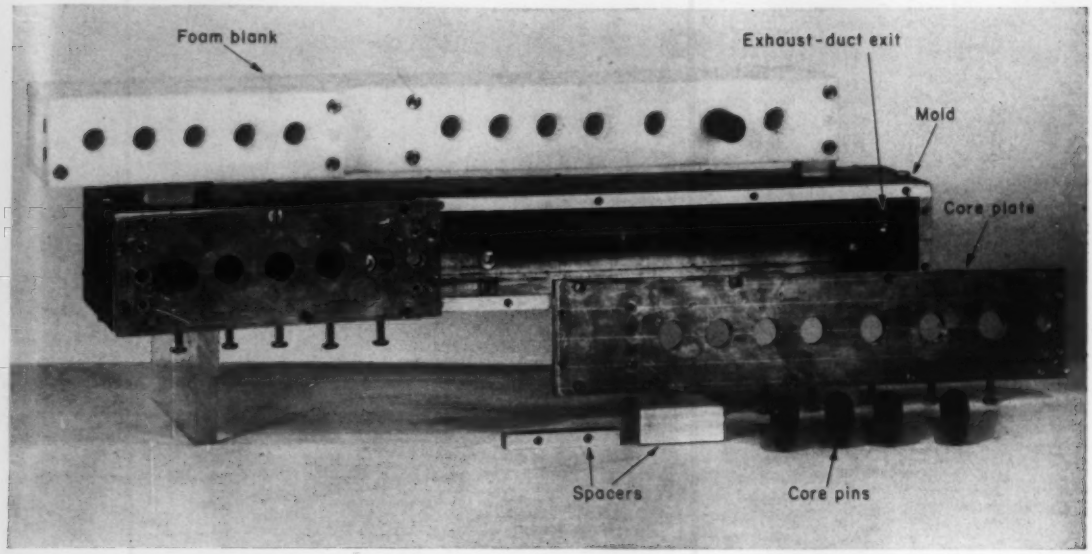


Fig. 4—Molds and associated hardware used to produce the foam blank for the component shown in Fig. 1. Components are later covered with a protective coating of special epoxy resin to guard against damage.

a silicone release agent and dried at 150 F. Any drying method is acceptable which leaves a smooth, bubble-free surface. Surfaces to which the foam is to adhere are coated with a compatible rubber-base adhesive and also dried. Sandwich-type constructions with glass cloth should be made with a peel-ply type of fabric. The surface exposed by removal of the cellophane or polyethylene film is sufficient for foam adhesion.

When mold surfaces are dry, the mold is tightly assembled, heated to 150 F, and maintained at that temperature until the foam batter is poured in or injected.

Foam Sampling: A small 20 to 30 gr sample of raw materials should be foamed prior to packaging. Because ambient conditions have a direct effect on foaming action, it is important that mixing time, viscosity, and color be recorded. Allowable mixing time depends on quantity of resin mixed, since exothermic heat rate depends upon mass. Ambient temperature and exothermic heat from the initial combination of components increase the speed of reaction.

Batter Preparation and Pouring: For laboratory work, small-batch mixes to 200 gr may be prepared by hand mixing in beakers or other small containers. Electric mixers are used for larger batches. Cautious handling of ingredients used in the mix is urged. Temporary respiratory irritation is caused by inhaling generated vapors.

A marked change in consistency and a release of exothermic heat indicate the beginning of foaming action. The batter must be poured at the proper consistency change which is just prior to the second stage of foaming. Experience will aid in recognizing the critical mixing point at which pouring should be started.

If mold design provides a pour opening of at least 1 sq in., the mix may be poured directly from the container into the mold. For smaller mold openings, a grease-gun type injector can be used to fill the mold under pressure through a hole as small as ½ in. in diameter. For large production runs, foam can be mixed, metered, and injected by machines which are commercially available. Temperature limitations of components to be potted should be determined before pouring, since momentary exothermic temperature rise may cause permanent damage of parts.

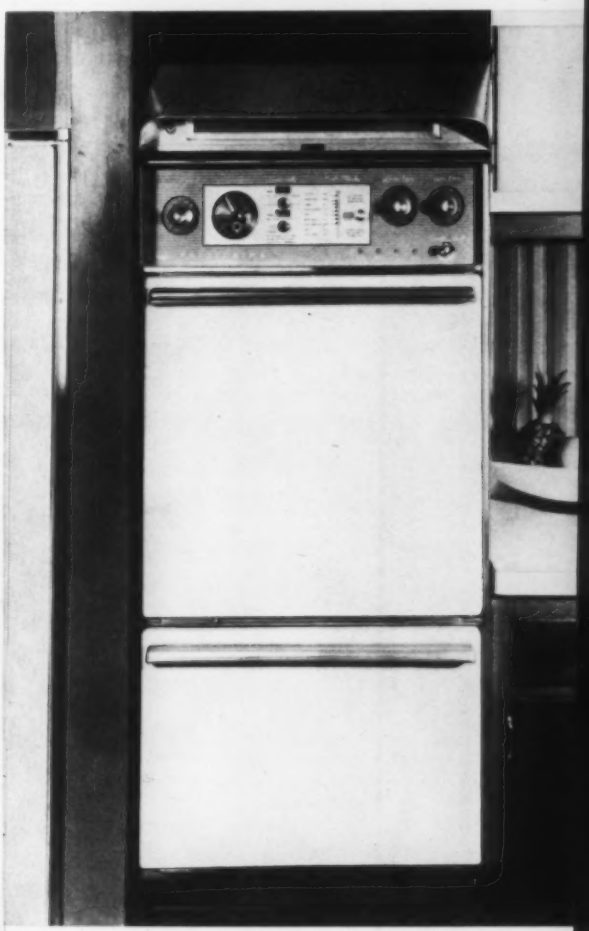
Controlling Foaming Action: When it is necessary to retard foaming action due to the complexity of the mold and the resultant difficulty in capping riser and filler holes, freshly powdered dry ice in small quantities can be mixed into the batch. The dry ice, chemically compatible with raw materials, lowers the temperature of the mixture almost immediately and retards foaming.

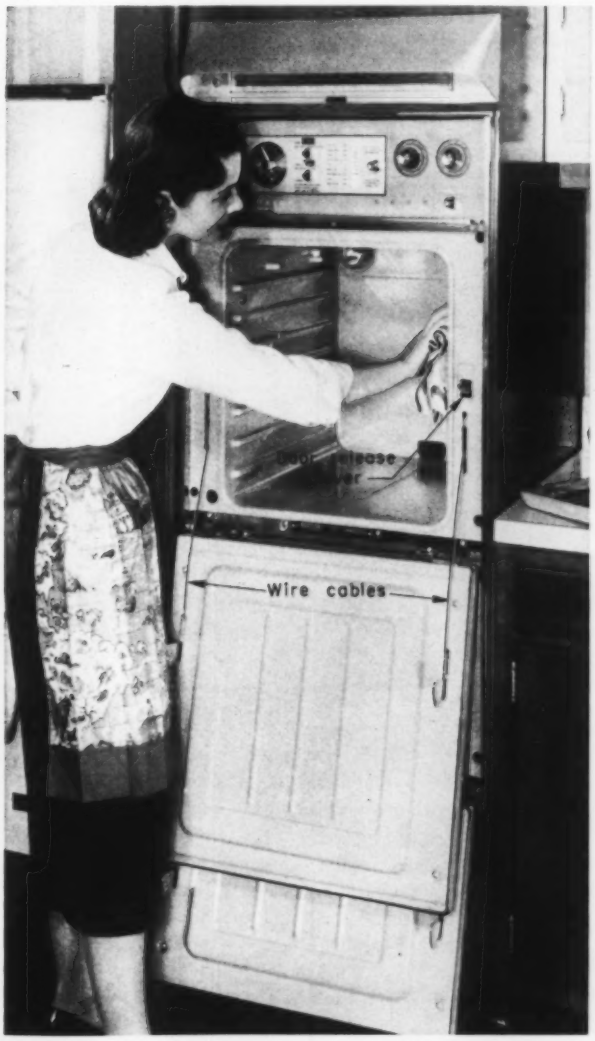
The rate of foaming with its resultant pressure is extremely important in foamed-in-place applications. Foam movement control in large complex molds is a process of selectively creating back pressure by plugging holes as the expanding foam approaches. When the foam reaches all riser holes, plugs are released and excess foam is allowed to escape from the mold.

When foaming ceases, the mold is allowed to cool to room temperature. It is then subjected to a curing temperature of 275 ±2 F for 3 hr. Both time and temperature control are necessary to obtain maximum physical properties of the foam. When the mold has again cooled to room temperature, excess foam may be removed from the mold before disassembly.

Drop-Leaf Door Design Simplifies Oven Cleaning

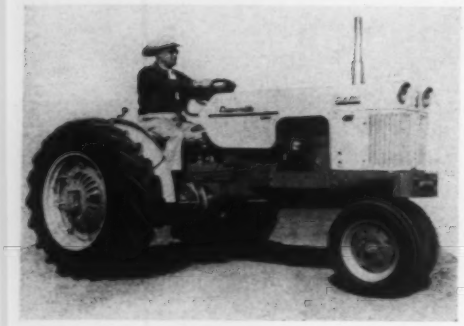
BUILT-IN WALL OVEN is designed by Frigidaire with "drop-leaf" doors, which not only serve as shelves for loading and unloading but also swing down all the way for easy cleaning. Release control levers on either side of the door permit them to be swung down, out of the way, like a drop-leaf table. Each door is supported by two airplane-type cables which can support ½ ton. When closed, the doors are held tight against the oven by spring-loaded rollers on either side.





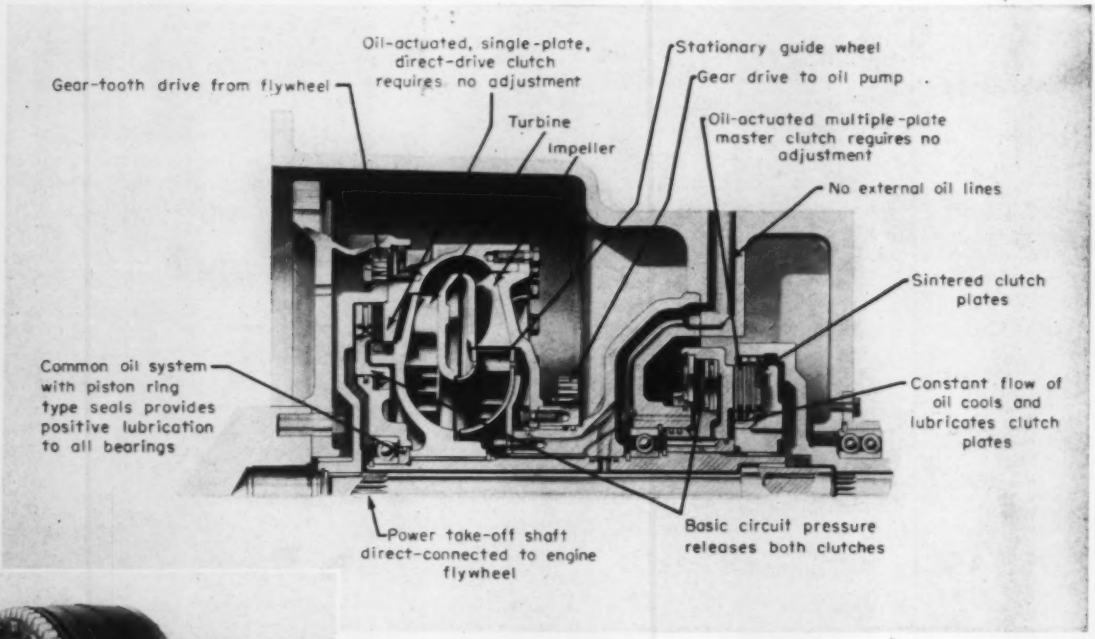
EASE OF INSTALLATION is another outstanding design feature of the new Frigidaire drop-leaf door wall ovens. After a simple electrical connection is made with a factory-supplied 54-in. armored cable, the oven can be slid into position and attached to the wall with four screws. There is no control panel or trim strip to take off or replace. Adjustable glides for quick leveling are provided on the bottom of the oven. Top controls are serviceable from the front by simply removing two screws, and the 54-in. cable is long enough to permit servicing of the oven, with power on, if withdrawn from wall cavity.

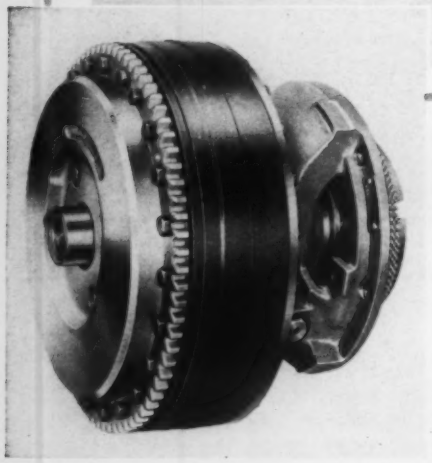
Automatic Adjustment of Tractor Pull



POWER-TRANSMISSION UNIT in a new line of Case farm tractors is designed to operate as either a torque converter or direct drive. Known as Case-O-Matic Drive, the transmission is now standard equipment in certain models of the line.

The key design feature is a "lockout" arrangement in the torque converter which permits changing the transmission into direct drive. Where torque multiplication is required or advantageous, the machine operates through the torque converter and produces nearly 100 per cent more drawbar pull than with direct mechanical drive. Where loads are relatively steady and can be handled by engine torque alone, without frequent shifting, the operator locks out the converter.


Oil-actuated, single-plate, direct-drive clutch requires no adjustment
Stationary guide wheel
Gear-tooth drive from flywheel
Gear drive to oil pump
Turbine
Impeller
Oil-actuated multiple-plate master clutch requires no adjustment
No external oil lines
Sintered clutch plates
Common oil system with piston ring type seals provides positive lubrication to all bearings
Constant flow of oil cools and lubricates clutch plates
Power take-off shaft direct-connected to engine flywheel
Basic circuit pressure releases both clutches



DIRECT DRIVE in the new torque-converter drive designed by Twin Disc is obtained by locking up the converter impeller to the turbine wheel. The single molded-asbestos driving plate has internal teeth which spline into a geared ring integral with the turbine.

A unique feature of the converter circuit is that direct drive is obtained with a stationary guide stage. Normally in converter design, when an impeller and turbine wheel are locked together, the guide stage is mounted on a freewheel so that it will rotate with the other two elements. If it were to be held stationary, a severe efficiency loss would be experienced. Twin Disc circuit designers, however, calculated the flow pattern of this circuit to permit a stationary guide wheel, thus eliminating need for a freewheel.

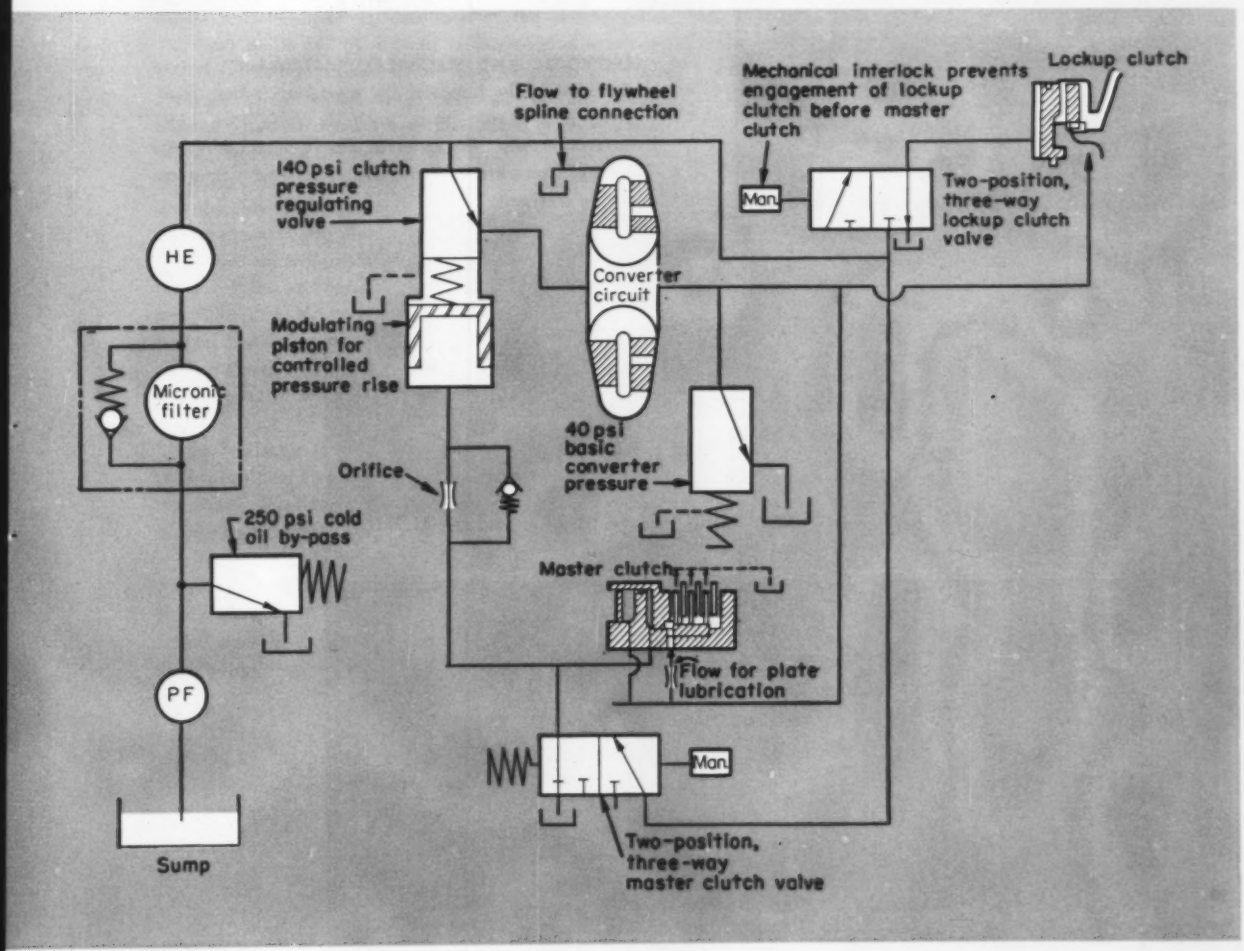
Obtained with Torque-Converter Drive

SMOOTH ENGAGEMENT OF CLUTCH PLATES is achieved with a pressure-regulating valve, which permits gradual pressure rise within the clutch cylinder. Oil is taken out of the sump by a gear pump and passed through a filter and heat exchanger. A 250-psi bypass is provided for cold weather operation to prevent damaging the system. Oil is directed into the pressure regulating valve, which in effect is a relief valve with a spring that can be variably loaded by another modulating piston. Spill from this valve feeds both the converter circuit and the release side of both clutch pistons with 40-psi oil pressure, which is maintained by use of a conventional spring-relief valve.

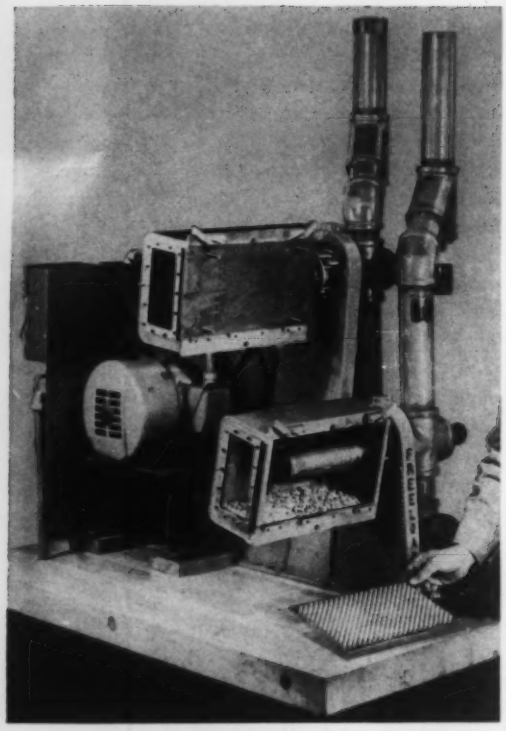
Upon opening the two-position, three-way valve to the master clutch, oil is directed to the pressure disc of the clutch piston. At the same time, the oil also travels through an orifice to the modulating piston which loads the regulating valve spring. As the spring is compressed, the supply pressure to the three-way valve is correspondingly increased. This action further increases the load on the regulating valve spring, by the modulating piston, and pressure is gradually increased until the modulating piston is stopped by a shoulder. At this point, the spring produces 140-psi pressure.

Upon releasing the master clutch, a ball check valve bypasses oil from the modulating piston so that it will not have to flow back through the restrictive orifice. Length of engagement time, of course, is controlled by the orifice diameter.

The lock-up clutch valve is simply a two-position, three-way valve. It acts independently of the pressure regulating valve, but a mechanical interlock prevents this valve from being engaged before the master clutch valve is operated.



Air Under Pressure Loads Parts



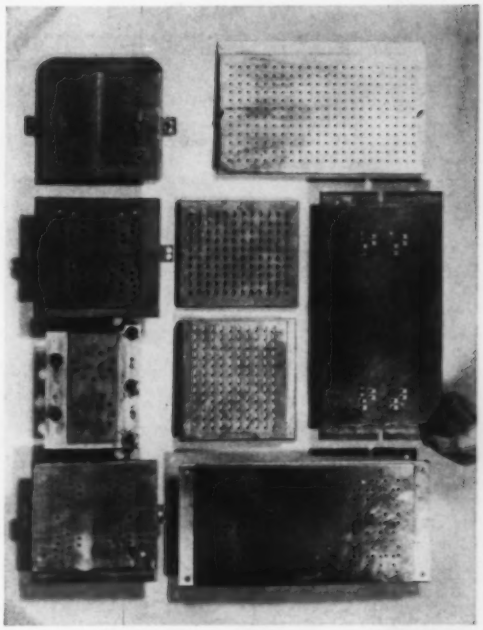
HIGH-SPEED AUTOMATIC LOADING of small parts or pieces in batch-at-a-time quantities is accomplished in a new machine developed by Whitso Inc., Schiller Park, Ill. The Freeloader, as it is known, uses a combination of mechanical and pneumatic action to "blow-load" small metal inserts on collector plates for molding operations.

ELECTRONIC AND ELECTRICAL "HARDWARE" typical of those easily handled by machine. Brass, steel, glass, and plastic parts, such as these, are automatically loaded on collector plates, eliminating the need of tweezers and manual or one-at-a-time assembly methods.

In Oscillating Collector Plate

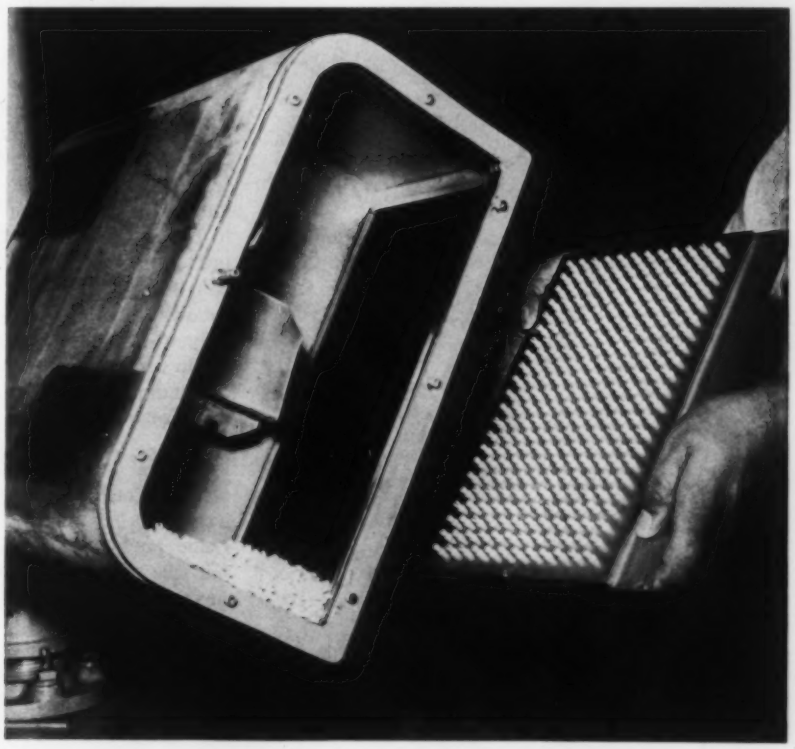
SPECIAL COLLECTOR PLATES for parts-loading machine are first designed for each application with holes made to the desired shape and pattern to accommodate the individual pieces being loaded. Careful design of chamfers, shoulders, and barriers in and around holes permits accurate positioning of parts and can further reduce loading time.

The collector plates can be used as a work holder for subsequent assembly operations, or the parts can be transferred to another fixture for further processing.



OSCILLATING RECTANGULAR DRUM is loaded at the beginning of the cycle with the desired parts. A collector plate, designed with holes of suitable shape and location, is clamped to one face of the drum. When the machine is set in motion, a chain drive starts the drum oscillating through a 240 deg arc, and air under pressure is introduced into the drum by an integral blower. The parts slide over the holes in the collector plate; the ends of the parts seek out the holes, and the flow of air carries the parts into the holes and holds them in place. When all holes are filled, the drum is parked and the collector plate is removed with a complete batch of parts in place.

The collector plate shown contains 264 nylon rivets. Loading can usually be accomplished in from 30 seconds to 3 minutes. Within reasonable limits, part size alone does not affect the loading time.



Complex Numbers

By R. S. HARTENBERG
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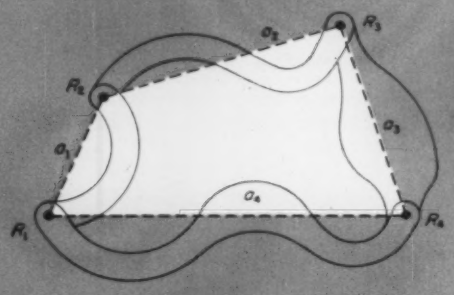

Fig. 1—Four-bar chain.

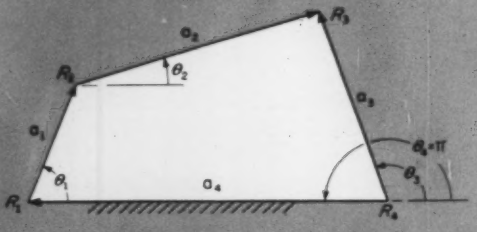

Fig. 2—Mechanism and vector polygon.

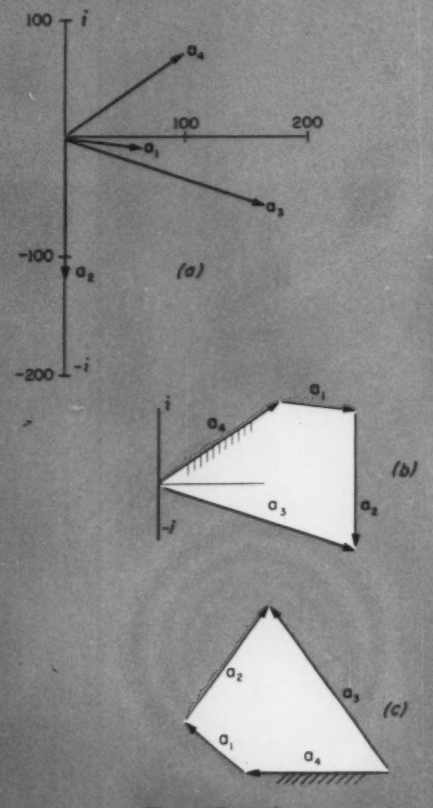

Fig. 3—Example 1.

IN A fundamental paper of fairly recent origin (1940), the Russian kinematician Bloch[1] applied complex numbers to the quantitative synthesis of four-bar linkages—specifically, the determination of link lengths meeting angular velocity and acceleration specifications. Enlargements on the technique have been principally in German.[2, 3, 4, 5-8] Rosenauer's treatment[8] of the subject in English was quite brief, and in addition appeared in an Australian journal not commonly available. Sieker[9, 10] and Rosenauer[11] have extended the method to the slider-crank by using the complex conjugate.

For the analysis of known four-bar linkages, Beyer[3] indicated the potential usefulness of the complex number. Martin and Spotts[12] have applied the complex number to the analysis of all types of planar mechanisms.

It is the vectorial representation of complex numbers that makes attractive any method using them, for often much of the physical nature of the problem is retained during the course of the solution. The power of the method and the fact that its use for synthesis is not generally known to readers of only English suggest that it be brought to their attention, with the warning, however, that not all problems of kinematics can be solved by the method. The treatment here follows Beyer[3] in the main, and will deal with only the four-bar linkage. A measure of the interest in complex numbers is shown by the References.

Fundamentals of complex numbers are reviewed in a separate discussion at the end of this article.

General Case: The four-bar kinematic chain consists of four turning pairs or pins having parallel axes— R_1, R_2, R_3, and R_4—held apart by four machine parts, the bars. The latter need not be as bar-like as they are ordinarily drawn. They could have any shape whatsoever, provided they are rigid and properly locate the pins, Fig. 1. The function of the parts is to positively locate successive pins with respect to each other. The schematic drawing of this four-bar chain would show

[1]References are tabulated at end of article.

and Four-Bar Linkages

. . . a method for finding link lengths that satisfy velocity and acceleration specifications

the pins connected by straight lines. This sketch may be interpreted as four points (the pin-axis intersections) in a plane having definite positions with respect to each other. Applying the idea that a complex number represents a point in a plane, we may then think of four numbers, one for each point, as a means of representing the chain. And since a complex number may also be represented by a vector, we may then invoke and exploit the useful properties of the latter.

If one link of a chain is fixed, Fig. 2, a mechanism results, and we can consider this mechanism as defined by four vectors, since there are four points. In fact, we now consider the mechanism to be shown by a closed vector polygon. For convenience, the vector senses are chosen such that the angles are positive (measured counterclockwise), and are less than or equal to π radians. Then $\mathbf{a}_4 + \mathbf{a}_1 + \mathbf{a}_2 = \mathbf{a}_3$, or

$$\mathbf{a}_1 + \mathbf{a}_2 - \mathbf{a}_3 + \mathbf{a}_4 = 0 \qquad (1)$$

Here the relation of one connection (pin) is given by the directed distances **a** (vectors).

Since a vector such as **a** may be written $\mathbf{a} = (a)e^{i\theta}$, where a is a distance and θ a ccw angle measured from the real axis, the vector equation of the polygon may be written in complex number form:

$$a_1 e^{i\theta_1} + a_2 e^{i\theta_2} - a_3 e^{i\theta_3} + a_4 e^{i\pi} = 0$$

The last term may be simplified since $e^{i\pi} = -1$; hence $\mathbf{a}_4 = -a_4$. Then

$$a_1 e^{i\theta_1} + a_2 e^{i\theta_2} - a_3 e^{i\theta_3} - a_4 = 0 \qquad (2)$$

This equation represents the space relation of the definitive points R_1, R_2, R_3, and R_4 or connections between links.

On differentiating with respect to time, setting $d\theta/dt = \omega$, and ordering,

$$i(a_1\,\omega_1)e^{i\theta_1} + i(a_2\,\omega_2)e^{i\theta_2} - i(a_3\,\omega_3)e^{i\theta_3} - a_4(0) = 0 \qquad (3)$$

The terms are recognized as defining the linear velocities of the points. This is then the velocity relation, and represents the velocity-vector diagram.

A second differentiation, after setting $d\theta/dt = \omega$ and $d\omega/dt = \alpha$, and ordering, yields

$$i(a_1\,\alpha_1)e^{i\theta_1} + i^2(a_1\,\omega_1^2)e^{i\theta_1} + i(a_2\,\alpha_2)e^{i\theta_2} + i^2(a_2\,\omega_2^2)e^{i\theta_2} - i(a_3\,\alpha_3)e^{i\theta_3} - i^2(a_3\,\omega_3^2)e^{i\theta_3} - 0(a_4) = 0 \qquad (4)$$

Here the factors $i(a_\alpha)$ and $i^2(a_\omega{}^2)$ are recognized as associated with the linear acceleration components of the points. Equation 4 is thus an acceleration relation involving the points; it represents the acceleration-vector diagram.

A more convenient form for future manipulation results on dividing by i and rearranging:

$$(\alpha_1 + i\omega_1^2)a_1\,e^{i\theta_1} + (\alpha_2 + i\omega_2^2)a_2\,e^{i\theta_2} - (\alpha_3 + i\omega_3^2)a_3\,e^{i\theta_3} - 0(a_4) = 0 \qquad (5)$$

On assembling Equation 2, 3, and 5 as a group, and replacing each $ae^{i\theta}$ by its vector **a**,

$$\left.\begin{aligned} 1\mathbf{a}_1 + 1\mathbf{a}_2 - 1\mathbf{a}_3 + 1\mathbf{a}_4 &= 0 \\ \omega_1\,\mathbf{a}_1 + \omega_2\,\mathbf{a}_2 - \omega_3\,\mathbf{a}_3 + (0)\mathbf{a}_4 &= 0 \\ (\alpha_1 + i\omega_1^2)\mathbf{a}_1 + (\alpha_2 + i\omega_2^2)\mathbf{a}_2 - (\alpha_3 + i\omega_3^2)\mathbf{a}_3 + (0)\mathbf{a}_4 &= 0 \end{aligned}\right\} \qquad (6)$$

This is a system of homogeneous equations in four unknowns—the vectors $\mathbf{a}_1$, $\mathbf{a}_2$, $\mathbf{a}_3$, and $\mathbf{a}_4$—in which some of the coefficients are not only complex numbers, but also involve the ω and α values of the links. In the solution of any system of equations, the unknowns are ultimately expressed in terms of their coefficients. Therefore, we may expect that the solution for the vectors **a** will define them in terms of i, ω, and α factors. In other words, each **a** will be dependent on specified values of ω and α, and will be given by a complex number. This, then, is quantitative synthesis, where specifications establish the link proportions. We might also say that this kind of synthesis is the transforming of an idea—the specifications—into hardware.

The solution of these equations involves the third-order determinants of the matrix of the coefficients, and cannot be detailed here. The links will be defined as complex numbers of the form $a = c + id$, whose real and imaginary parts are themselves defined by the specified angular velocities

Table 1—Four-Bar Linkage

Vector or Link $\mathbf{a}$	Real Component c	i Component d	Complex Form $\mathbf{a} = c + id$	Length $a = \sqrt{c^2 + d^2}$
$\mathbf{a}_1$	$c_1 = \omega_3 \alpha_2 - \omega_2 \alpha_3$	$d_1 = \omega_2 \omega_3 (\omega_2 - \omega_3)$	$\mathbf{a}_1 = c_1 + id_1$	$a_1 = \sqrt{c_1^2 + d_1^2}$
$\mathbf{a}_2$	$c_2 = \omega_1 \alpha_3 - \omega_3 \alpha_1$	$d_2 = \omega_3 \omega_1 (\omega_3 - \omega_1)$	$\mathbf{a}_2 = c_2 + id_2$	$a_2 = \sqrt{c_2^2 + d_2^2}$
$\mathbf{a}_3$	$c_3 = \omega_1 \alpha_2 - \omega_2 \alpha_1$	$d_3 = \omega_1 \omega_2 (\omega_2 - \omega_1)$	$\mathbf{a}_3 = c_3 + id_3$	$a_3 = \sqrt{c_3^2 + d_3^2}$
$\mathbf{a}_4$	$c_4 = c_3 - c_1 - c_2$	$d_4 = d_3 - d_1 - d_2$	$\mathbf{a}_4 = c_4 + id_4$	$a_4 = \sqrt{c_4^2 + d_4^2}$

and accelerations specified for the links. The perfectly general results defining the vectors—links—are put up in Table 1.

When the vectors represented by the complex numbers are assembled in order (see Examples), they will define the proportions of a mechanism having the specified velocity and acceleration values. In general, the fixed link (in this case $\mathbf{a}_4$) will not "come out horizontal," even though the basic sketch, Fig. 2, placed it that way; $\mathbf{a}_4$ will generally have an i component, which means a position-rotation. However, all links will be rotated by the same amount. This is a consequence of having had to assume, during the course of the solution of the equations, that a factor of proportionality common to all links was equal to unity. That it really is not unity gives a consistent rotation of all vectors forming the mechanism. Unity or not, the relative lengths of the vectors are unchanged.

If the inputs to the definitions of Table 1 are incompatible with physical reality, then no mechanism will result in the sense that a vector of zero length will be given, or the vectors will not "close." "Ask a silly question, get a silly answer." The definitions cannot be called upon without some regard for sensible and compatible magnitudes, but poor estimates are found and revised quickly.

Examples: The application of the method of complex numbers for the synthesis of four-bar linkages meeting angular velocity and acceleration specifications will be given in some examples. When making entries into the Table 1 definitions of the components, it must be remembered that the positive directions of angular velocity and acceleration are the same as the positive directions for the angles from which they derive. Positive is counterclockwise.

EXAMPLE 1: To determine the links of a four-bar mechanism that will in one of its positions satisfy the following specifications:

$\omega_1 = 8$ rad per sec $\quad \alpha_1 = 0$ rad per sec^2
$\omega_2 = 1 \quad \alpha_2 = 20$
$\omega_3 = 3 \quad \alpha_3 = 0$

Substituting values into the Table 1 definitions,

$$\mathbf{a}_1 = c_1 + id_1 = 3(20) - 1(0) + i(1)(3)(1 - 3)$$
$$= 60 - i(6)$$
$$a_1 = 60.297 \text{ units}$$

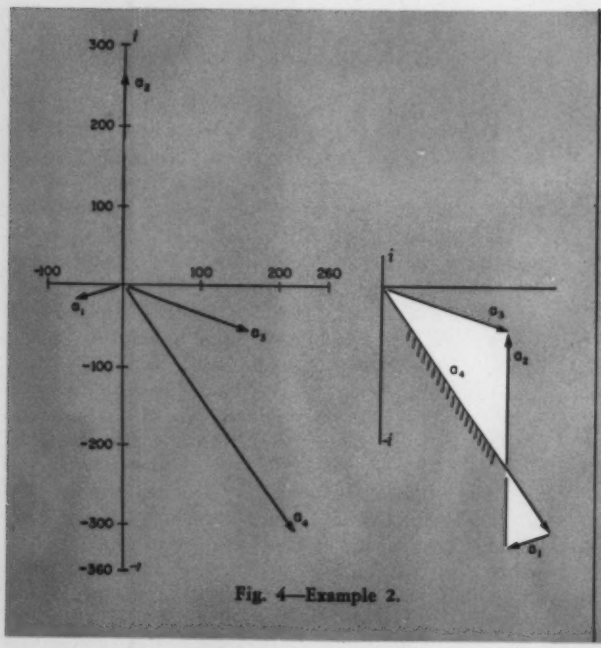

Fig. 4—Example 2.

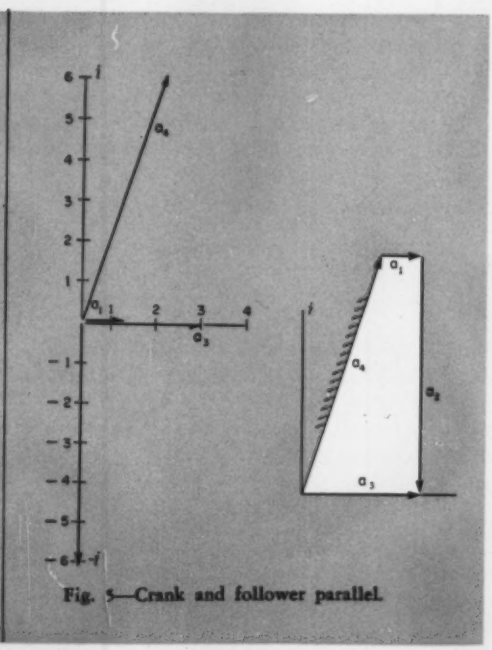

Fig. 5—Crank and follower parallel.

$$\mathbf{a}_2 = c_2 + id_2 = 8(0) - 3(0) + i(3)(8)(3 - 8)$$
$$= 0 - i(120)$$
$$a_2 = 120.000 \text{ units}$$

$$\mathbf{a}_3 = c_3 + id_3 = 8(20) - 1(0) + i(8)(1)(1 - 8)$$
$$= 160 - i(54)$$
$$a_3 = 168.867 \text{ units}$$

$$\mathbf{a}_4 = 160 - 60 - 0 + i(-54 + 6 + 120)$$
$$= 100 + i(72)$$
$$a_4 = 123.286 \text{ units}$$

The vectors represented by the complex numbers are shown in Fig. 3*a*. The mechanism is formed by assembling the vectors in sequence, starting with $\mathbf{a}_4$, Fig. 3*b*. The proportions of a mechanism responding to the specified motion characteristics are now on a relative basis. The mechanism has appeared with a rotation, a consequence of a mathematical manipulation which is of no moment to our physical problem. The relative lengths of the bars and their terminal points have been established as functions of the specified ω and α values. Needless to say, the bar $\mathbf{a}_4$ must always be the fixed link. For the sake of convention the mechanism may be straightened up, Fig. 3*c*. An analysis of this mechanism will verify the fact that the specifications have been met.

EXAMPLE 2: To determine the mechanism whose specifications differ from that of Example 1 only in that $\omega_3 = -3$ rad per sec. This means that link $\mathbf{a}_3$ would rotate clockwise. Substitution then defines the links as follows:

$$\mathbf{a}_1 = -3(20) - 1(0) + i(1)(-3)(1 + 3)$$
$$= -60 - i(12)$$
$$a_1 = 61.187 \text{ units}$$

$$\mathbf{a}_2 = 8(0) - (-3)(0) + i(-3)(8)(-3 - 8)$$
$$= 0 + i(264)$$
$$a_2 = 264.000 \text{ units}$$

$$\mathbf{a}_3 = 8(20) - 1(0) + i(8)(1)(1 - 8)$$
$$= 160 - i(54)$$
$$a_3 = 168.867 \text{ units}$$

$$\mathbf{a}_4 = 160 - (-60) - 0 + i(-54 + 12 - 264)$$
$$= 220 - i(306)$$
$$a_4 = 376.038 \text{ units}$$

This mechanism is shown in Fig 4.

Special Cases: In the general case so far considered, no attention has been paid to the position or configuration that the mechanism might have when meeting the velocity and acceleration specifications. We simply took the configuration that resulted. However, by considering geometric aspects of the links, it is possible to specify some feature of configuration, as parallelism of crank and follower, in addition to imposing certain velocities and accelerations.

CRANK AND FOLLOWER PARALLEL: If a_1 and a_3 are crank and follower, then parallelism is stated by $\theta_1 = \theta_3$, a condition that can be expressed by the components of the complex numbers defining the associated links a_1 and a_3 as $d_1/d_3 = c_1/c_3$ or $d_1 = d_3 c_1/c_3$. Then if $\omega_1 \neq 0$, $\omega_2 = 0$, $\omega_3 \neq 0$, $\alpha_1 = 0$, $\alpha_2 \neq 0$, and $\alpha_3 = 0$, the Table 1 values reduce to

$$\mathbf{a}_1 = \omega_3 \alpha_2 + 0$$
$$\mathbf{a}_2 = 0 + i\omega_1 \omega_3(\omega_3 - \omega_1)$$
$$\mathbf{a}_3 = \omega_1 \alpha_2 + 0$$
$$\mathbf{a}_4 = (\omega_1 - \omega_3)\alpha_2 + i\omega_1 \omega_3(\omega_3 - \omega_1)$$

Since the complex numbers defining $\mathbf{a}_1$ and $\mathbf{a}_3$ consist of only real parts, and the number for $\mathbf{a}_2$ is only the imaginary part, it is apparent that $\mathbf{a}_1$ and $\mathbf{a}_2$ are parallel, and that $\mathbf{a}_2$ is furthermore perpendicular to both.

As an example, assume the following: $\omega_1 = 3$, $(\omega_2 = 0)$, $\omega_3 = 1$, $(\alpha_1 = 0)$, $\alpha_2 = 1$, $(\alpha_3 = 0)$ (radian-second units). The links are then $\mathbf{a}_1 = 1$, $\mathbf{a}_2 = -6i$, $\mathbf{a}_3 = 3$ and $\mathbf{a}_4 = 2 + i6$ units.

This mechanism is shown in Fig. 5. It is immediately obvious from instant center considerations that $\mathbf{a}_2$ has motion of translation in this configuration. Also, the link lengths a_1 and a_2 must vary inversely as their angular velocities.

We may note also that if $\omega_1 = \omega_2$, then $a_1 = a_3$ and $a_2 = 0$, $a_4 = 0$. This is the trivial case.

If Table 1 is asked to handle incompatible situations, then an impossible mechanism results. Thus, if it is specified that $\omega_2 \neq 0$ in addition to calling for parallelism of crank and follower, it becomes impossible to fulfill all conditions. Thus, with

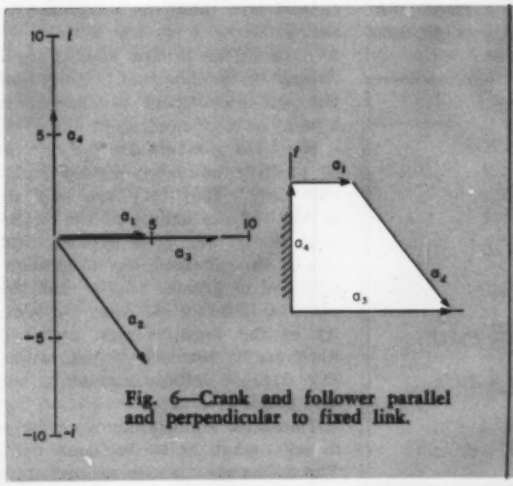

Fig. 6—Crank and follower parallel and perpendicular to fixed link.

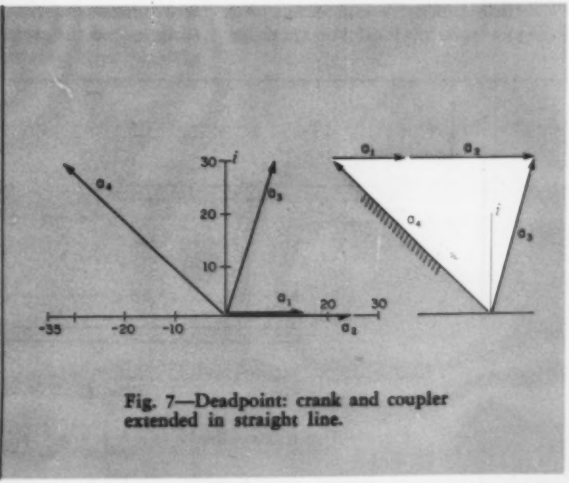

Fig. 7—Deadpoint: crank and coupler extended in straight line.

$\omega_1 = 3$, $\omega_2 = 2$, $\omega_3 = 1$, $\alpha_1 = 0$, $\alpha_2 = 2$, and $\alpha_3 = 2$ (radian-second units), the resulting mechanism has the links $\mathbf{a}_1 = -3 + i\,3$, $\mathbf{a}_2 = 6 - i\,6$, $\mathbf{a}_3 = 3 - i\,3$, $a_4 = 0$. Here the links a_1 and a_3 are parallel, and a_2 connects them properly, but a_4 does not exist. The linkage forms a structure of three finite but connected bars. With a different incompatibility, the last bar might not connect with the first bar.

CRANK AND FOLLOWER (1) PARALLEL AND (2) PERPENDICULAR TO FIXED LINK: These conditions will be fulfilled if (1) $\theta_1 = \theta_3$ (that is, $d_1/d_3 = c_1/c_3$ or $d_1 = d_3c_1/c_3$) and (2) if $\theta_1 + 90 = \theta_4$ (that is, $c_4/d_4 = -d_1/c_1$) or $c_4 = -d_1d_4/c_1$. We could reasonably expect to ask for $\omega_1 \neq 0$, $\omega_2 = 0$, $\omega_3 \neq 0$, $\alpha_1 \neq 0$, $\alpha_2 \neq 0$, and $\alpha_3 \neq 0$. The link values then reduce to

$$\mathbf{a}_1 = \omega_3\,\alpha_2 + 0$$
$$\mathbf{a}_2 = \omega_1\,\alpha_3 + i\omega_3\,\omega_1(\omega_3 - \omega_1)$$
$$\mathbf{a}_3 = \omega_1\,\alpha_2 + 0$$
$$\mathbf{a}_4 = \left(-\frac{d_1\,d_4}{c_1} = 0\right) - i\omega_3\,\omega_1(\omega_3 - \omega_1)$$

The imposing of condition 2 means less freedom in the choice of the motion specifications. For the real parts of the vectors to sum to zero means that $c_1 + c_2 = c_3$ or $\omega_3\alpha_2 + \omega_1\alpha_3 = \omega_1\alpha_2$. From this it is seen that we may specify three of these four quantities (ω_1, ω_3, α_2, α_3) to establish the fourth.

As an example, assume $\omega_1 = 3$, ($\omega_2 = 0$), $\omega_3 = 1.2$, ($\alpha_1 = 0$), $\alpha_2 = 2.7$ (radian-second units).

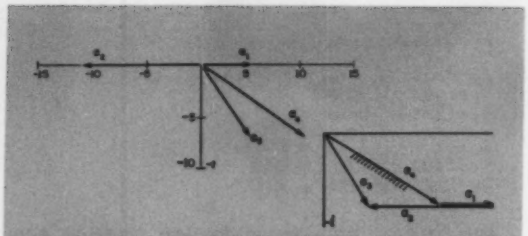

Fig. 8—Deadpoint: crank and coupler folded over each other.

$$\alpha_3 = \frac{\omega_1\,\alpha_2 - \omega_3\,\alpha_2}{\omega_1}$$

$$= 1.62 \text{ rad per sec}^2$$

With these specifications the links are found to be $\mathbf{a}_1 = 3.24$, $\mathbf{a}_2 = 4.86 - i\,6.48$, $\mathbf{a}_3 = 8.10$ and $\mathbf{a}_4 = i\,6.48$ units. The mechanism is shown in Fig. 6.

DEADPOINTS: A deadpoint occurs when the follower is momentarily at rest just prior to reversing its direction of rotation; that is, when $\omega_3 = 0$. With continuously rotating crank, the crank and coupler are either (1) extended in a straight line, or (2) folded over each other into a straight line. Condition 1 calls for $\theta_1 = \theta_2$, whence $d_1/d_2 = c_1/c_2$ or $d_1 = d_2c_1/c_2$. Condition 2 requires that $\theta_1 + 180 = \theta_2$, for which $d_1 = d_2c_1/c_2$ also ap-

The Complex Number in Kinematics

THE complex number is often a very useful tool for certain procedures of kinematic synthesis and analysis because of the geometric interpretations that may be attached to it. Mathematical procedures are developed from rules and definitions, and the procedures are meaningful only if both rules and definitions are observed. To avoid misunderstandings, it is always good to restate the rules and definitions to make sure that all the thinking is fundamentally the same.

The Ordinary Number: A review of the properties of, and the operations with, ordinary or real numbers will help in the consideration of the complex numbers. We may give an ordinary or real number a geometric interpretation. An ordinary or real number corresponds to the distance—positive, negative or zero—measured from a fixed point (origin) on a given straight line.

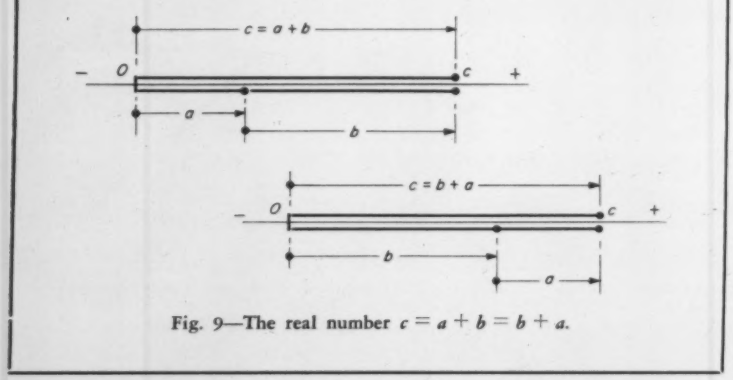

Fig. 9—The real number $c = a + b = b + a$.

Furthermore, an ordinary or real number such as c is defined as the sum of two other real numbers, and is then written $c = a + b$. The geometric interpretation of $a + b$ is this: The line segment a is to be laid off to the right (from an agreed-upon point designated as the origin), and the line segment b is to be laid off to the right from the end of a, Fig. 9. We note that it will make no difference to the value of c if we write $c = b + a$. This is like adding logarithms on a slide-rule. Note that the one-dimensional number c is a point on a given straight *line*.

Negative numbers are the reverse of positive numbers; geometrically this means that they are laid off to the left, as shown in the examples in Fig. 10. If it happens that one of the numbers, say b, is negative and of greater length than the positive a, then c will have the quality of the negative sign and will itself be to the left of the origin, Fig. 11; $-c$ defines a point on the straight line.

The plus sign is an operator—it tells what is to be done next. The minus sign is also an operator;

plies. If $\omega_1 \neq 0$, $\omega_2 \neq 0$, $(\omega_3 = 0)$, $\alpha_1 \neq 0$, $\alpha_2 \neq 0$, and $\alpha_3 \neq 0$, the link values reduce to

$$\mathbf{a}_1 = -\omega_2 \alpha_3 + \left(d_1 = \frac{d_2 c_1}{c_2} = 0 \right)$$

$$\mathbf{a}_2 = \omega_1 \alpha_3 + 0$$

$$\mathbf{a}_3 = \omega_1 \alpha_2 + i\omega_1 \omega_2(\omega_2 - \omega_1)$$

$$\mathbf{a}_4 = \omega_1 \alpha_2 + \omega_2 \alpha_3 - \omega_1 \alpha_3 + i\omega_1 \omega_2(\omega_2 - \omega_1)$$

Example, Condition 1—crank and coupler extended in a straight line: Here ω_2 will be negative, with α_2 and α_3 both positive. Consider a mechanism in which $\omega_1 = 3$, $\omega_2 = -2$, $(\omega_3 = 0)$, $(\alpha_1 = 0)$, $\alpha_2 = 8/3$, and $\alpha_3 = 8$ (radian-second units). The links are then $\mathbf{a}_1 = 16$, $\mathbf{a}_2 = 24$, $\mathbf{a}_3 = 8 + i\,30$ and $\mathbf{a}_4 = -32 + i\,30$ units. This mechanism is shown in Fig. 7.

Example, Condition 2—crank and coupler folded over each other into a straight line: Here ω_2 and α_2 will be positive, with α_3 negative. Consider a mechanism in which $\omega_1 = 3$, $\omega_2 = 1.5$, $(\omega_3 = 0)$, $(\alpha_1 = 0)$, $\alpha_2 = 1.7$ and $\alpha_3 = -3.7$ (radian-second units). The links are then $\mathbf{a}_1 = 5.55$, $\mathbf{a}_2 = -11.10$, $\mathbf{a}_3 = 5.10 - i\,6.75$, and $\mathbf{a}_4 = 10.65 - i\,6.75$ units. The mechanism is shown in Fig. 8.

Closure: This treatment of the four-bar is still incomplete. Further possible uses of the complex number might include matters such as the optimum transmission angle, coupler perpendicular to frame, and maximum and minimum values of output velocity when the input velocity is constant. However, some idea of the power and beauty of the method has been indicated, and may give rise to still further applications.

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A Mechanisms Conference Paper

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it calls for a reversal of the lay-off direction, or a turn through 180 deg, and we will agree that positive angles shall be measured in the counterclockwise (ccw) sense. Formally, we might write that this reversal of b is $(-1)b$: it is customary, however, to write only $-b$. By not writing the (-1), sight is often lost of the real meaning of the minus sign as a direction-reversing operator. The digit 1 merely says that the physical length of b remains unchanged during the operation of reversal. However, this operation of going negative is a very important one, and hence the emphasis on it by way of Fig. 12.

The ordinary or real number c is then by geometrical interpretation, one-dimensional: It represents a point on a line, a co-ordinate, and results from certain operations on the real numbers a and b signaled by the plus and minus signs.

The Complex Number: To represent a point in a plane there is the two-dimensional number called the complex number. It is written $c = a + ib$. This equation contains a new operator i, which has the following meaning: After laying off a, lay off b and turn it ccw through 90 deg, Fig. 13. In this scheme, a is called the real part of c, and is laid off along the real axis; ib is called imaginary part of c, and is laid off along the axis of imaginaries. Both a and b are real numbers. If a is zero but b is not, then c lies on the i axis; if b is zero but a is not, then c lies on the real axis. The upper part of the axis of imaginaries is labeled $+i$, corresponding to the ccw 90-deg turn already mentioned. The lower branch is labeled $-i$, and corresponds to a ccw turn of 270 deg.

The real axis to the left has been considered negative. Now we have seen that this negative branch corresponds to a reversal or ccw 180-deg turn or (-1). Since 180 deg is a 90-deg turn plus another 90-deg turn, the (-1) is interpreted as i^2. Then i^2 represents two successive operations with i (each being a ccw 90-deg turn), and we write that $i^2 = -1$. With this interpretation the $-i$ branch (ccw 270 deg) is $(-1)i = i^3$. Some mul-

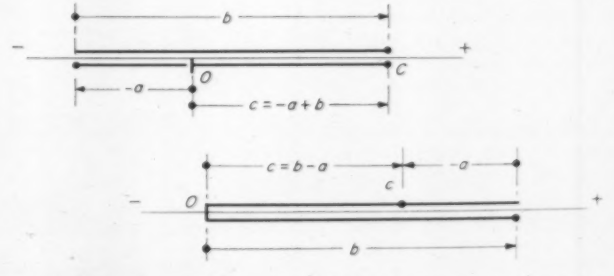


Fig. 10—The real number $c = -a + b = b - a$, where $|a| < |b|$.

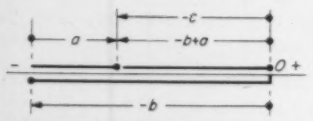


Fig. 11—Real number $-c = -b + a = a - b$, where $|a| < |b|$.

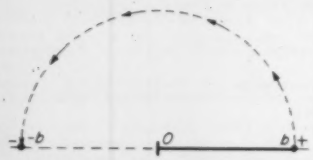


Fig. 12—Minus sign as an operator, signaling a ccw turn of 180 deg. It is a direction reverser.

tiple values of i associated with the various axes are shown in Fig. 14. The important thing to remember is that i is an operator calling for ccw 90-deg turn every time that it appears, as $i^2 = -1$ means ccw 180 deg, $i^3 = i^2 i = (-1)i = -i$ or ccw 270 deg, and so on. Note that the angles are always measured in the ccw direction.

Suppose that in Fig. 15 the length or distance between O and the point defined by the complex number c is r. Under geometric interpretation, we may also add the following:

$a = r \cos \theta$, distance along the x axis

$b = r \sin \theta$, distance along the i axis

θ = arc tan b/a, ccw angle

$r = \sqrt{a^2 + b^2}$, distance from O to c.

We recognize that Oc is a vector, the directed distance r. The direction and length of this vector **Oc** depend on the position of the point defined by c, or we may write (since we start from the origin) that $\mathbf{Oc} = a + ib = r(\cos \theta + i \sin \theta)$. Since it may be shown that $(\cos \theta + i \sin \theta) = e^{i\theta}$ [also, $e^{-i\theta} = (\cos \theta - i \sin \theta)$], we may write the vector $\mathbf{Oc} = (r)e^{i\theta}$. The expression $(r)e^{i\theta}$ is then a shorthand for saying that there exists a vector of length r directed at an angle θ. The end of the vector is the point c. Our interest lies in this point c; the vector is only the means of locating this point c with respect to the origin of the vector. We are thus able to locate one point with respect to another by writing $(r)e^{i\theta}$. The angle θ is always measured ccw from the positive real axis.

The Complex Number and Links of Constant Length: For the purpose of kinematics we may consider the vector **Oc** to be a link turning about O. Our interest clearly lies in the motion that the point c has with respect to the point O. This motion can be investigated by returning to the vector property of Oc, and exploiting this property by successive differentiation to find the (linear) velocity and acceleration of c with respect to O. The position of the vector is given by the angle θ, its length by r, Fig. 16. If the vector turns about its end O, then its velocity is given by a vector of length $r\omega$ whose direction is perpendicular to the vector **Oc**, with the sense controlled by the direction of ω. The velocity vector is the directed distance between the point c and the end V of the vector whose length is $r\omega$ (to some scale).

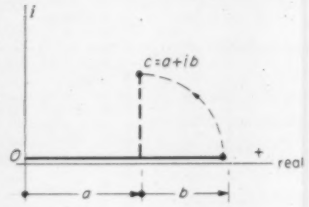


Fig. 13—The complex number $c = a + ib$.

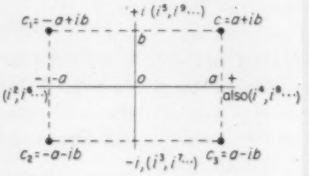


Fig. 14 — Complex numbers in quadrants.

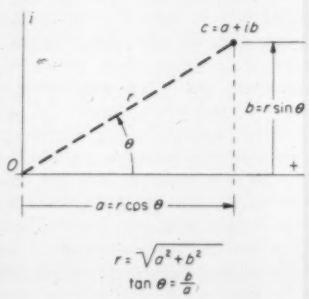


Fig. 15—The geometric meaning of the complex number $c = a + ib$.

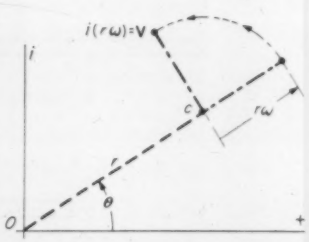


Fig. 16—The meaning of $(d/dt)[(r)e^{i\theta}] = i(r\omega)e^{i\theta} = \mathbf{V}$.

Writing the vector **Oc** as $(r)e^{i\theta}$ and differentiating (r = constant, since the link length is not changing),

$$\frac{d}{dt}\left[(r)e^{i\theta}\right] = (r)e^{i\theta} i \frac{d\theta}{dt}$$

$$= (r)e^{i\theta} i\omega$$
$$= i(r\omega)e^{i\theta}$$
$$= \mathbf{V}$$

Returning to the geometric interpretation, this expression means that we have a (new) vector of length $r\omega$ whose angle of inclination is not θ but $\theta + 90$ (the i signaling the 90 deg), as shown in Fig. 16. We realize that we have located the point V with respect to the point c, and that V is a complex number. The directed distance between the two is only the conventional way of representing the linear velocity of the point c. We should note that the origin of the vector **V** is at the point c.

As for the acceleration, which will appear in terms of rectangular components, the situation will be similar. The linear acceleration components of the endpoint c are

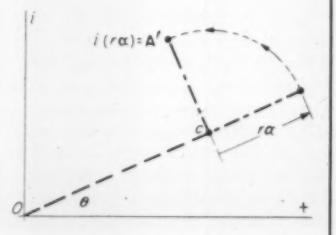


Fig. 17—The meaning of $(-1)(r\omega^2)e^{i\theta} = \mathbf{A}^n$.

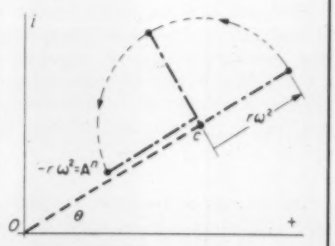


Fig. 18—The meaning of $i(r\alpha)e^{i\theta} = \mathbf{A}^t$.

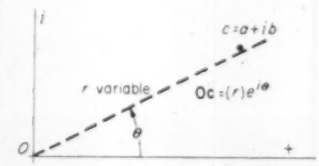


Fig. 19—The point c moving with respect to rotating line.

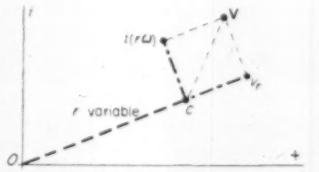


Fig. 20—The meanings of $i(r\alpha)e^{i\theta}$ and $(v_r)e^{i\theta}$.

known to us as $\mathbf{A}^n = r\omega^2$, directed along the vector toward O, and $\mathbf{A}^t = r\alpha$, directed perpendicular to the vector $\mathbf{Oc}$ with a sense controlled by the direction of α, where $\alpha = d\omega/dt$.

Differentiating the linear velocity (again r = constant),

$$\frac{d}{dt}\left[\, i(r\omega)e^{i\theta} \,\right] = (ir\omega)e^{i\theta}\, i\,\frac{d\theta}{dt} \twoheadrightarrow (ire^{i\theta})\,\frac{d\omega}{dt}$$

$$= i^2(r\omega^2)e^{i\theta} \twoheadrightarrow i(r\alpha)e^{i\theta}$$

$$= (-1)(r\omega^2)e^{i\theta} \twoheadrightarrow i(r\alpha)e^{i\theta}$$

$$\mathbf{A} = \mathbf{A}^n + \mathbf{A}^t$$

Geometrically, the first term $\mathbf{A}^n$ is a vector of length $r\omega^2$ whose inclination is $\theta + 180$, the $i^2 = (-1)$ accounting for the 180-deg turn that directs $\mathbf{A}^n$ through O, Fig. 17. The second term $\mathbf{A}^t$ is a vector of length $r\alpha$ whose inclination is $\theta + 90$, Fig. 18. It lies along the line of the velocity vector, and its sense follows that of α. We realize that the endpoints $\mathbf{A}^n$ and $\mathbf{A}^t$ have been located with respect to the point c. They are complex numbers. We note that the origins of the vectors $\mathbf{A}^n$ and $\mathbf{A}^t$ are at the point c.

The Complex Number and Sliders: The foregoing has dealt with the motion of a point always a fixed distance from another. That is, the point c was always the constant distance r from the reference point O. We saw that this corresponded to a bar of fixed length and was recognized in the differentiations by setting r = constant. This allows the study of pin-connected plane linkages.

If we now permit r to be a variable distance, thus allowing the point c to wander along the line of the radius, we come to the idea of the kinematic slider moving along a straight link, i.e., the rectilinear motion of a crosshead with respect to its rotating guide (the straight link). We may study this situation in the following manner:

Consider the rotating line (vector), Fig. 19, along which the point c is moving. The position of c is then given by instantaneous values of r and θ, both of which vary with time. Then, as before, the position of c may be written $c = (r)e^{i\theta}$. Differentiating, but now with r and θ as variables,

$$\frac{d}{dt}\left[\, (r)e^{i\theta} \,\right] = (r)e^{i\theta}\, i\,\frac{d\theta}{dt} \twoheadrightarrow (e^{i\theta})\,\frac{dr}{dt}$$

$$\mathbf{V} = i(r\omega)e^{i\theta} \twoheadrightarrow (v_r)e^{i\theta}$$

where v_r is the velocity of c along (with respect to) the line, and ω the angular velocity of the line. The components of $\mathbf{V}$, and $\mathbf{V}$ itself, are shown as points in the plane. The lines from c to these points are the familiar vector representation of the velocity configuration, Fig. 20.

Differentiating the foregoing expression will lead to the acceleration of the point c. In the first term there are three variables, r, ω, and θ; in the second term the variables are v_r and θ. Remembering that the derivative of a product of several variables is given by

$$d(uvw\ldots) = \left(\frac{du}{u} + \frac{dv}{v} + \frac{dw}{w} + \ldots\right) uvw\ldots$$

we will have, on differentiation of the expression for $\mathbf{V}$,

$$\frac{d}{dt}\left[\, i(r\omega)e^{i\theta} + v_r e^{i\theta} \,\right]$$

$$= i\left[\frac{dr}{dt}\frac{1}{r} + \frac{d\omega}{dt}\frac{1}{\omega} + e^{i\theta}\, i\,\frac{d\theta}{dt}\frac{1}{e^{i\theta}}\right] r\omega e^{i\theta} +$$

$$\left[\, (v_r)e^{i\theta}\, i\,\frac{d\theta}{dt} + (e^{i\theta})\,\frac{dv_r}{dt} \,\right]$$

$$\mathbf{A} = i(v_r\,\omega)e^{i\theta} + i(r\alpha)e^{i\theta} + i^2(r\omega^2)e^{i\theta} + i(v_r\,\omega)e^{i\theta} + (a_r)e^{i\theta}$$

The sum of the first and fourth terms is recognized as the Coriolis acceleration; this is perpendicular to the line Oc because of the i. The second term is the usual $\mathbf{A}^t$, also perpendicular to the line; the third term is the usual $\mathbf{A}^n$, directed toward O because of the i^2 or -1. The last term is the acceleration of the point along the line. We then have

$$\mathbf{A} = \mathbf{A}^{cor} + \mathbf{A}^t + \mathbf{A}^n + \mathbf{A}^{n_r}$$

These quantities—really points defined by complex numbers—are shown in Fig. 21 for positive values of the several variables.

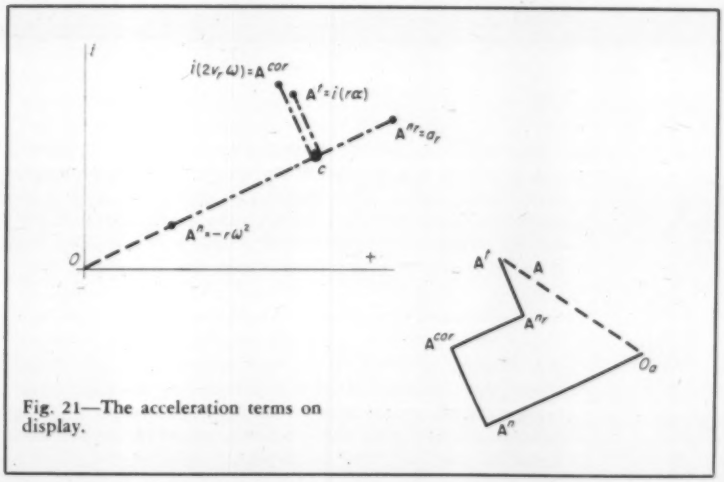


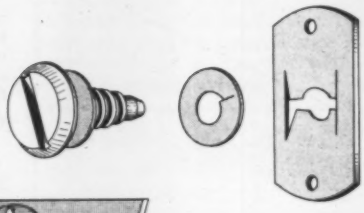
Fig. 21—The acceleration terms on display.

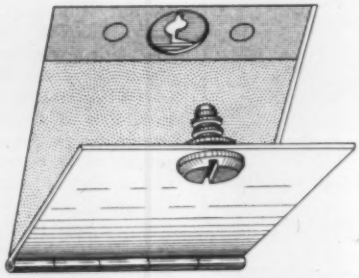
Summary: The consideration of the complex number—a point in a plane—has developed interesting analytic properties that are seen to yield linear velocity and acceleration information. In consequence, the use of the complex number offers an often convenient method for studying the relative motion of points in planar mechanisms for both synthesis and analysis.

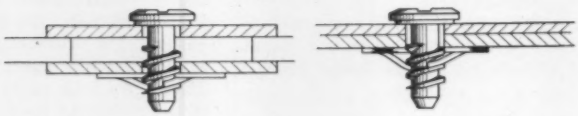
The complex number has other uses of which no mention has been made. Here only the immediately useful information for kinematics has been presented.

PANEL FASTENERS

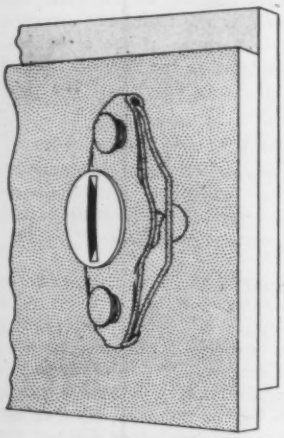
Developed to simplify assembly and disassembly of panels, access doors and other similar design elements, panel fasteners can be adapted to a wide range of application requirements where accessibility is an important consideration. Representative types and applications of fasteners manufactured by the Southco Div. of South Chester Corp. are shown in the accompanying illustrations. Available forms vary from latches to quick-opening fastener types. Although details of construction and operation differ, all are designed for "captive" mounting and provide a positive locking action in assembly. In application, the fasteners are suitable for either occasional or frequent operation and can be locked or unlocked by turning the head or handle manually or with a simple form of assembly tool.

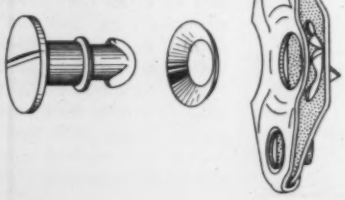


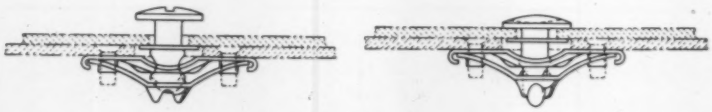




Screw-type quick-opening fastener provides a rugged panel joint with a wide tolerance for misalignment. Fastener assembly consists of a square-threaded screw engaging a spring-action locknut. The locknut is clipped, riveted or welded to the main structure. A special washer behind the thread holds the screw in an oversize hole in the panel or door. This construction permits the screw to "float" in the hole, simplifying assembly and keeping the fastener operative even when the joint members are deformed. Variations in grip length due to different material thicknesses or elasticity of the joint are readily accommodated by the design which can be tightened down to form a solid, vibration-resistant assembly. Under most conditions, the screw will completely disengage in two to four turns. Head styles include slotted, knurled and wing.

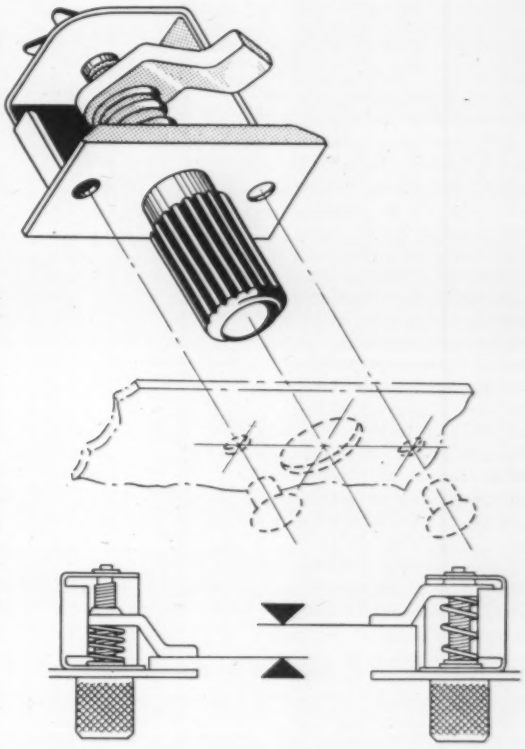




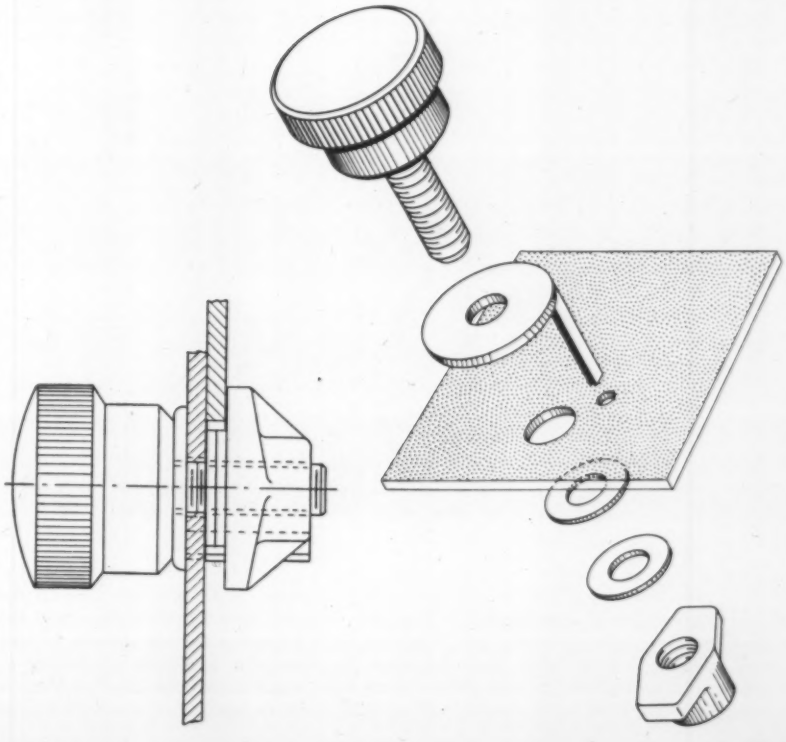


Quarter-turn quick-opening fastener develops a vibration-resistant spring-locking action to hold panel members tightly under compression. It is quickly locked or unlocked by a fractional turn of the head. Fastener assembly consists of a solid stud which is retained in the door or panel by a metal grommet and engages a full-floating, spring-loaded receptacle riveted or welded to the main structure. Some misalignment and thickness variation in the joint members can be accommodated by the design; however, it is best suited to applications where the thickness of joint members can be expected to remain fairly uniform. Several head styles, as well as light and heavy duty constructions, are available to meet different assembly and appearance requirements.

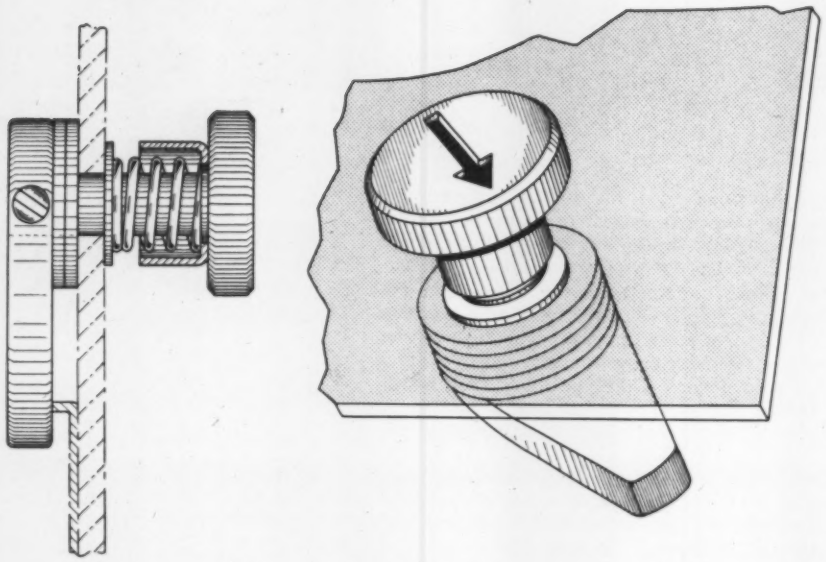
Adjustable pawl fastener is designed for application on frequently opened access doors. In assembly, three holes are drilled through the door, the knob of the preassembled unit is passed through from the inside, and the mounting plate is bolted, riveted or welded to the main structure. Variations in door and frame thickness are accommodated by a take-up adjustment on the operating knob which can be tightened after closing to provide a secure, dust-sealed joint. Design options include flush head style for screwdriver assembly, right and lefthand units, different body sizes and grip lengths, and a modified construction for installation where inside clearance or mounting space is limited.

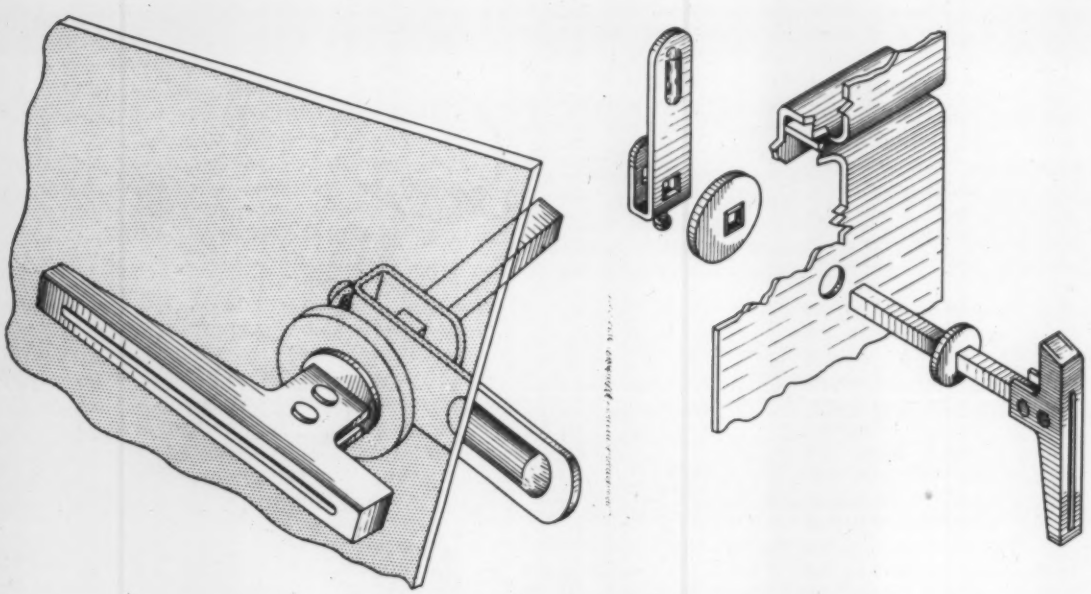


Adjustable panel latch offers a low-cost fastener with advantages in assembly and appearance. For assembly, two holes are punched in the panel or door. Screw and pawl stop are inserted from one side and the pawl nut tightened in place on the other. A quarter turn of the screw locks or unlocks the fastener which latches against the main structure, eliminating the need for a striker plate. Additional torque applied after the latch is engaged "pulls up" the panel or door to form a sealed, vibration-resistant joint. Panel thickness variations are accommodated by spacer washers under the pawl nut. Lightweight and compact, the design is particularly suited for use on electronic equipment, instruments and closures where quick access and neat finished appearance are desired. Options include wing, round, and knurled-plastic heads.

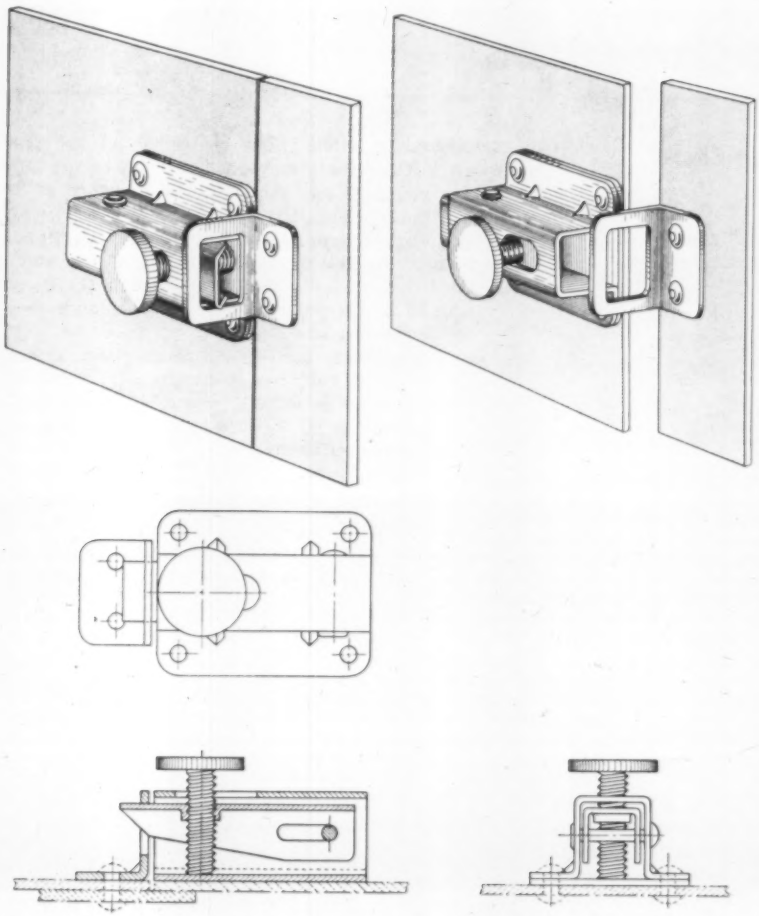


Arrowhead latch is recommended for fastening slide-out drawers and removable or hinged panels. A quarter turn of the knob locks or unlocks the fastener which requires minimum inside space for assembly. Doors or panels are held in place under spring-action; a slight pressure against the knob releases it for rotation. Only a single drilled hole is required for assembly of the latch; no additional fastening elements are necessary. Different panel and frame thicknesses are compensated by spacer washers under the latch pawl. Position of the pawl is indicated by the arrow on the knob, eliminating the need for a pawl stop.



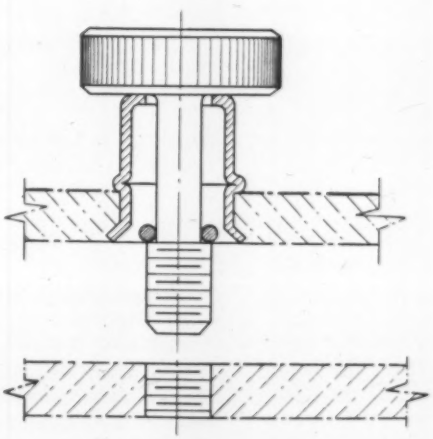


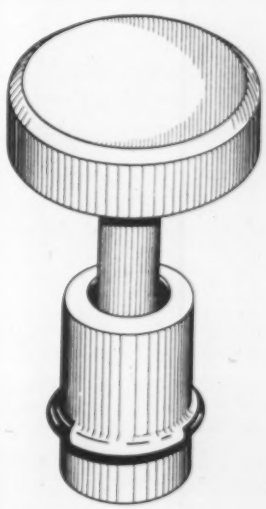
Universal cabinet latch is installed by inserting stem through hole in door or panel and pushing home a spring steel clip to lock assembly in place. Pawl latch is held in place by a set screw and can be readily adjusted for any length to meet design requirements. Handle shape indicates latch position, eliminating need for a stop. Attractive in appearance, the design is recommended for application on sheet metal panels or doors. A slotted-head construction with arrow indicator is also available.



Sliding latch is designed for external mounting where inside space is limited or other conditions, such as sanitation requirements, do not permit interior installation. Operation of the latch is controlled through a screw attachment on the pawl or tongue which engages a keeper mounted to the main structure. The pawl assembly is riveted to the door or panel surface. After pawl slides or drops into keeper, it can be tightened against the striker surface by turning the screw knob. This action seals the door and frame under pressure to form a tight, vibration - resistant joint. Latch construction does not require precision alignment in assembly and can accommodate tolerance variations in the joint elements without affecting operation. A modified unit for inside mounting and external operation is also available.

Retractable screw fastener is designed for attaching component drawers and panels to master units. Principal application has been in modular units for electronic equipment. Fastener assembly consists of a screw which engages a tapped hole in the frame, a flanged sheet-metal bushing or "stand-off," and a plastic O-ring. Stand-off is mounted by flaring in punched or drilled hole in panel or door. Screw is then inserted in stand-off and held in place by O-ring. The screw can be fully retracted within the stand-off for panel removal but remains attached to the door. In addition, the screw "floats" in its oversize hole, providing play for misalignment takeup. This feature simplifies assembly problems when several fasteners are employed on the same door or panel.

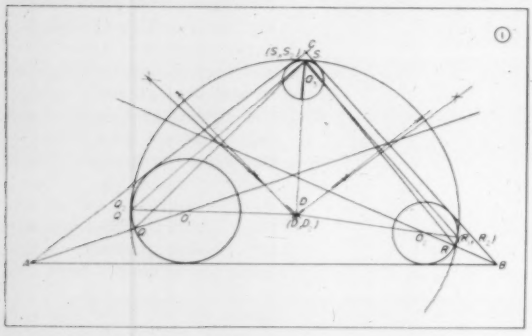




Tips and Techniques

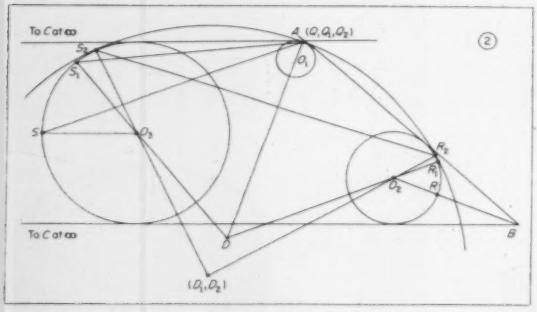
Circumscribing Three Circles

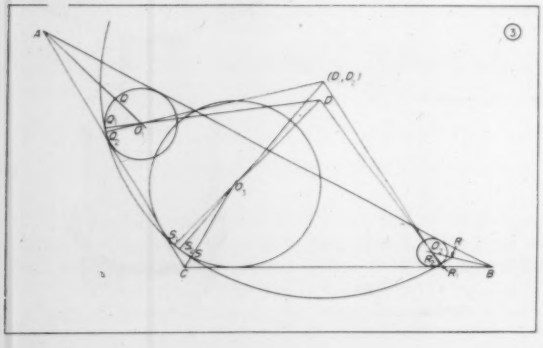
To circumscribe a circle tangent to any three given circles of unequal diameters, the solution may be found by graphically finding the three tangent points on the given circles by successive approximations that progressively approach the true tangent points. Any desired accuracy can



be achieved by successive approximations, but rarely are more than three needed.

Let O_1, O_2, O_3 be the centers of the given circles. Common tangents of two circles are drawn to form the triangle ABC. Bisectors of the angles A, B, and C, are then drawn to intersect the given circles at points Q, R, and S, respectively. The circle through points Q, R, and S is the first approximation of the required



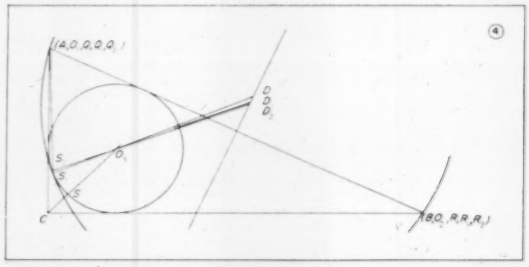


circumscribing circle. The center, D, of the circle drawn through the points QRS is found as the intersection point of the perpendicular bisectors of the sides of the triangle QRS.

For a better approximation, lines are run from D through O_1, O_2, and O_3 to obtain points Q_1, R_1, and S_1, on the given circles. The circle through Q_1, R_1, and S_1, with D_1 as the center, is the closer, second approximation of the desired circle.

For a practically perfect and much closer approximation, lines are run from D_1 through O_1, O_2, and O_3 to obtain tangent points Q_2, R_2, and S_2 on the circles. The circle through Q_2, R_2, and S_2, with D_2 as center, is the final circumscribing circle.

The usual case, where the common tangents form a well-defined triangle, is shown in Fig. 1. Letters in brackets indicate nearly coincident points that cannot practically be separated. A case where



two of the tangents are parallel is given in Fig. 2. Intersecting circles are given in Fig. 3, and a case where two of the circles have degenerated into points (O_1 and O_2) in Fig. 4.—K. S. RANGASWAMI and C. G. RAY, *Mechanical Engineering Dept., Indian Institute of Technology, Kharagpur, India.*

Simple Backlash Calculation

Backlash which occurs when two perfectly meshing gears are separated by a distance, d, is almost equal to $3d/4$ for 20-deg pressure angle gears and is a little greater than $d/2$ for $14\frac{1}{2}$-deg pressure angle gears.

The exact values are

$$B = 2d \tan \phi$$

when ϕ is the pressure angle. — ARNE BENSON, *Sanders Associates Inc., Nashua, N. H.*

Correction-Fluid Dam

When making corrections on films with correction fluid, a mask of Zip-A-Tone or Axtype material will prevent the fluid from running onto areas where changes are not desired.—THOMAS D. REID, *engineering draftsman, Aeronautical Communications Equipment Inc., Miami, Fla.*

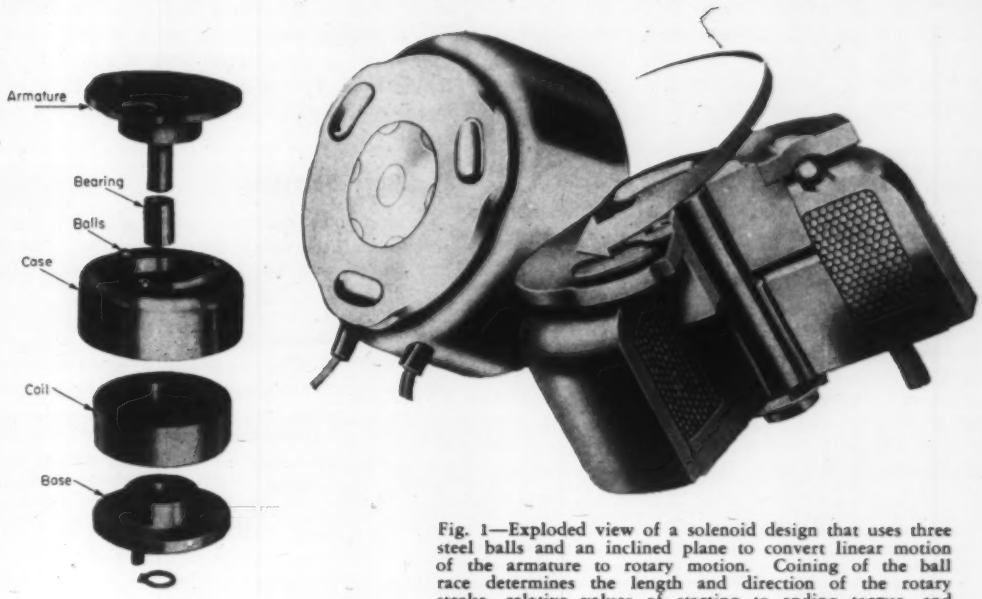


Fig. 1—Exploded view of a solenoid design that uses three steel balls and an inclined plane to convert linear motion of the armature to rotary motion. Coining of the ball race determines the length and direction of the rotary stroke, relative values of starting to ending torque, and other special characteristics.

Applying

Rotary Solenoids and Selectors

By JAMES R. DUNBAR and ARNOLD L. CROUCH
G. H. Leland Inc., Dayton, Ohio

PROPER application of rotary solenoids and selectors requires a clear understanding of their design and operating characteristics and limitations. Equally important are complete data on the power source, mounting conditions, load factors, environmental factors, etc. This article covers the many design considerations involved in applying dc rotary solenoids and selectors.

▶ Rotary Solenoids

The type of rotary solenoid shown in Fig. 1 employs one of the oldest mechanical devices—the inclined plane. A strong electromagnetic pull tends to close an air gap, thus drawing the armature in. Since the armature is supported by three steel balls that travel around and down in three inclined ball races or grooves, the armature is forced to rotate by cam action.

Rotation continues until the balls have traveled to the deep ends of their respective races. This action results in a low-friction conversion of power from straight pull to a rotary motion through the use of the inclined plane.

Magnetic Pull: Push-pull solenoids develop a rapidly-increasing amount of magnetic pull as the air gap closes. The magnetic pull of the rotary solenoid also increases sharply as the air gap closes, but this is compensated for by the compound angle of incline of the ball race. In other words, at the beginning of the stroke the incline is steep and gradually decreases as the balls ap-

proach the end of the race. Thus, the torque-producing components of force at the steep end of the ball race incline can be made equal to the torque-producing force components at the shallow end of the ball-race incline, Fig. 2.

Rotary Stroke: The coining of the ball race determines the length and direction of the rotary stroke, the relative values of starting to ending torque, and other special characteristics which may be desired. Standard strokes for solenoids of the type shown in Fig. 1 are 25, 35, 45, 67½, and 95 deg.

Torque Versus Length of Stroke: Torque is inversely proportional to the total length of the rotary stroke. For example, if a solenoid is selected to provide a starting torque of 5 lb-in. with a 45-deg stroke, the same solenoid under identical conditions will develop a starting torque of almost 10 lb-in. if it has a 25-deg stroke. The solenoid has a certain amount of work it can do whether this work is distributed over a short or long rotary stroke. This conversion of axial force to torque is accomplished by almost frictionless ball bearings.

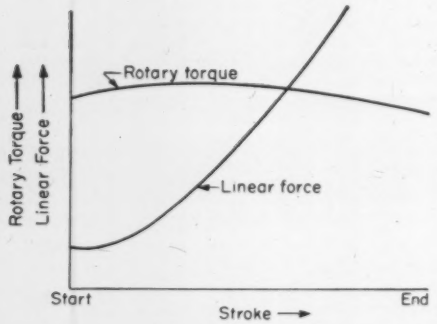


Fig. 2—Effect of converting linear output to rotary output in rotary solenoids. Inclined ball races of the solenoid compensate for the magnetic pull increase as the air gap closes, providing substantially equal starting and ending torque during the rotary stroke.

Rotary Selectors

A complete assembly that includes the rotary solenoid, interrupter switch, ratchet mechanism, and wafer switches is known as a rotary selector, Fig. 3.

Rotary-Solenoid Drive: A rotary solenoid, such as shown in Fig. 1, can provide the mechanical power to drive the gang of rotary, wafer-type switches. When the coil is energized, the moving member of armature is drawn into the coil. At the same time, the inclined ball races cause the armature to rotate.

Commutating Switch: The cam-operated interrupter or commutating switch, combined with the action of an armature return spring, causes a rapid self-imposed oscillation of the solenoid. The switch-operating cam is moved by an arm on the driving ratchet, and backlash in this connection causes a lag between the action of the solenoid and action of the switch.

The final result is that the switch remains closed until the last few degrees of the solenoid power stroke, when it is opened, breaking the circuit to the solenoid coil. The interrupter switch then is held open until the solenoid is within just a few degrees of the de-energized position where it is closed to "make" the circuit and repeat the cycle.

Ratchets: Ratchet mechanisms provide a method of power take-off whereby a load can be indexed

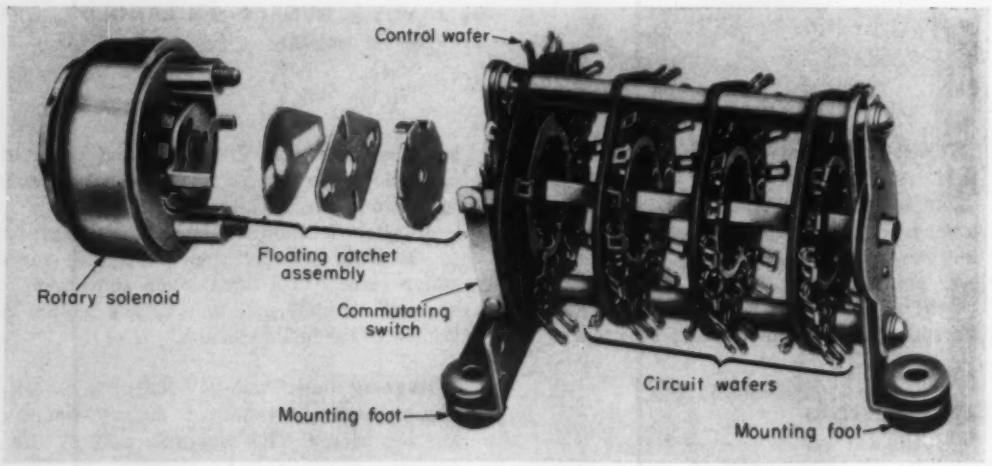
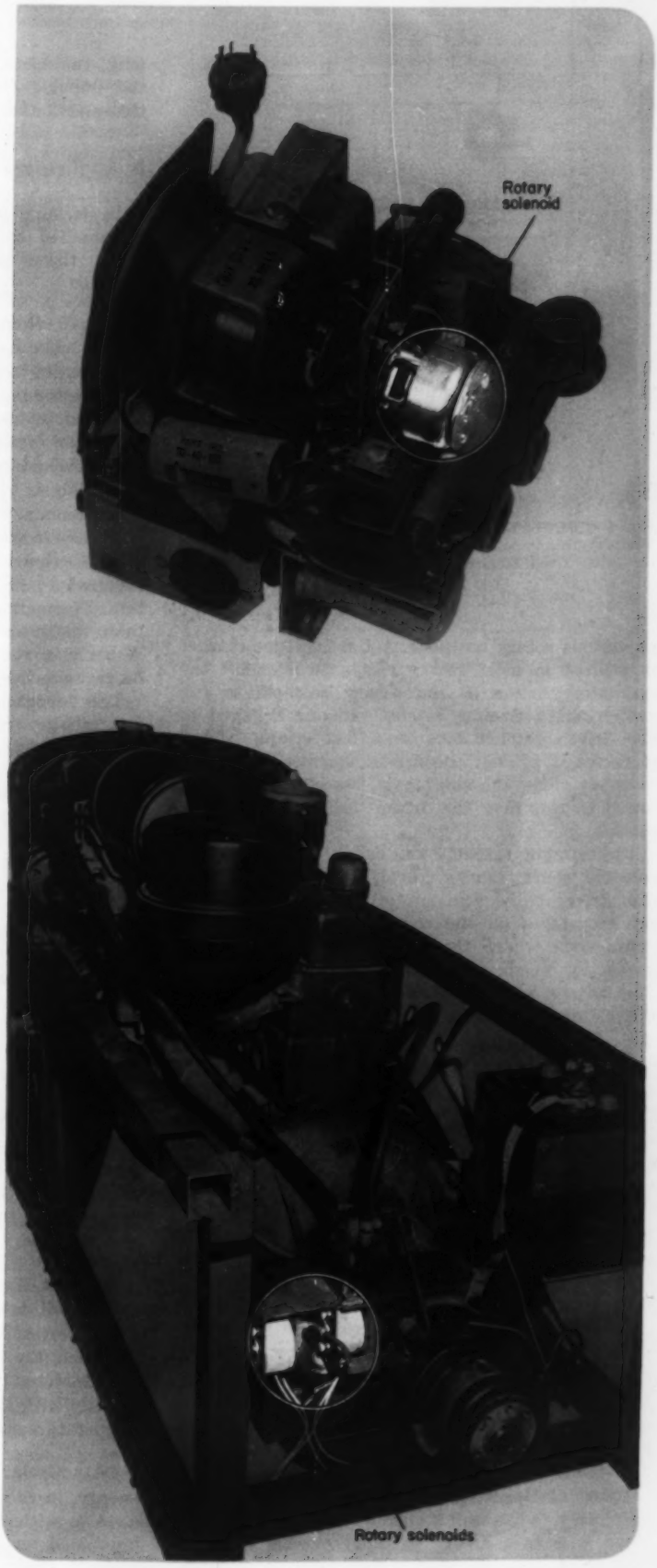


Fig. 3—Rotary-solenoid operated wafer-type selector switch. Rotational power is transmitted to the switch shaft through the ratchet mechanism. Switch rotors are indexed to the next contact position by each actuation of the solenoid.

When the microphone switch is placed in the dictate position, a rotary solenoid turns a rotary switch which connects the proper circuit elements for this tape dictation machine to record. When the solenoid is in the de-energized position, the rotary switch connects the amplifier components required for play-back. The machine is manufactured by Felt and Tarrant Mfg. Co., Chicago, Ill.

Applications of rotary solenoids in the Dynassist unit, which is a packaged booster made by the Wolf Engineering Co., Dallas, Tex., providing supplemental power for tractor-trailer combinations. One solenoid is used as a carburetor control; the other shifts a stage of reduction gearing in the mechanical drive mechanism. Both are controlled by electrical switches in the cab. The packaged power booster is located by the rear wheels.



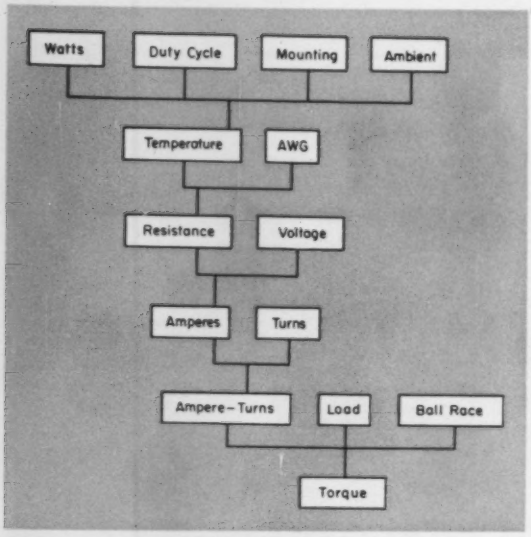


Fig. 4—Chart of factors affecting torque in rotary solenoids. Temperature, amperes, ampere-turns, and torque depend on the other fixed factors.

to various rotary positions. A floating-type ratchet is utilized in most rotary relays to transmit the oscillating action of the rotary solenoid to the switch shaft. Such a ratchet remains engaged to the driven ratchet because a leaf spring behind it forces it against the driven member. It is free to move along the shaft axis, however, and is allowed to ride over the driven teeth on the return stroke.

Disengaging ratchets are solidly riveted to the solenoid shaft. Linear travel of the shaft allows this driver to be completely disengaged from the driven ratchet on the return stroke. This is advantageous where the load must be turned, at times, by means other than the rotary solenoid. This is true with supplementary manual control or bidirectional operation of rotary relays.

Wafer Sections: One or more of the wafer-type rotary switch sections are mounted on the shaft driven by the solenoid. The control wafer is usually the first wafer nearest the solenoid. Generally, it is used in the control circuit along with the solenoid coil and commutating switch.

Many combinations and switching patterns are possible by using one or more of these switches in a gang. Remote control of the rotary solenoid presents many unique answers to heretofore unsolved remote control problems.

The wafer sections of selectors of this type are produced in combinations of 8, 10, 12, 18, and 24 positions or "throw" for use with the circuit selector. Because of their wider versatility and higher production, the 12 and 18-position type represent the most economy.

Speed of Operation: Speed of indexing the circuit relay, when self-stepping, is from 35 to 40 steps a second. Under external pulsing or stepping, the speed generally depends on the cycle of the impulse (the relationship between the "off" time and "on" time of the switch).

Application Factors

In deciding whether a particular application can be handled successfully by these rotary components, there are a number of design factors to consider.

Torque Requirements: Probably the foremost factor to be considered in a rotary-solenoid application is its torque requirement. The designer must select a component with sufficient power to match the load which he has established in his design. All other factors involved in the operation of rotary solenoids revolve around this torque requirement, Fig. 4.

A secondary torque function which may be a necessary consideration is the amount of hold-in torque required. Hold-in torque is that amount required to hold the load in its operational position. Normally, this torque is substantially less than that required at the start of the operation. If such is the case, then a hold-in resistor can be recommended for protection of the solenoid.

The function of a hold-in resistor is to reduce the voltage across the solenoid coil at the end of the rotary stroke. This is accomplished by providing a switch which will be actuated the instant the solenoid has reached its full stroke. When actuated, the switch places the resistor in series with the solenoid coil, thus reducing the coil voltage. The size of this resistor depends on how much hold-in torque is required.

Power Source: Since rotary solenoids and selectors of the types discussed here are direct-current devices, they must be operated from a dc power source or from an ac power source through a suitable rectifier.

The voltage range must be known to supply the proper wire size in the solenoid coil. If the power-source voltage fluctuates, the coil wire gage must be that required for the lowest voltage expected. A solenoid with the coil wound properly would produce the required torque even though its impressed voltage were low in value. Coils can be provided to accommodate almost any voltage requirements.

Ambient Temperature Range: Since resistance of the coil determines the amount of current produced for a particular voltage, the temperatures to which the components will be subjected must be considered. The resistance of copper wire varies directly with the temperature. Therefore, at higher temperatures, the resistance will be higher.

Duty Cycle: Duty cycle controls the amount of energy, in the form of heat, that the solenoid will have to withstand. If a given amount of power is impressed on a solenoid for too long a period or

at too frequent intervals, the temperature rise within the solenoid may cause it to exceed its temperature limitations. Even though this limitation may not be reached, the resistance will be affected. This will affect the torque because the temperature rise and the ambient temperature add together. Therefore, duty cycle is likewise an important factor to consider in the proper operation in a rotary-solenoid application.

Mounting: The method of mounting a solenoid ties in directly with temperature-rise limits, duty cycle and electric power input. Heat dissipation depends largely on surface area. The greater the area, the faster the heat dissipation and the lower the temperature rise. When a solenoid is mounted properly—with its base drawn down tight against the mounting surface—the mounting surface area will add to that of the solenoid to increase its cooling abilities.

Specific relationships between solenoid size, mounting-plate size, power input, and temperature rise have been obtained through extensive research. Some of the results are shown in Fig. 5. Sufficient wattage was impressed on different sized solenoids, which were attached to various sized $\frac{1}{8}$-in. aluminum plates, to produce an 80 C temperature rise. Plate sizes are related to the diameters of the solenoids. Fig. 5 illustrates the effect of mounting surface area on temperature rise. Note that for each size solenoid the watts input can be more than doubled, and in some cases tripled, with sufficient mounting surface without increasing the temperature rise.

To remove heat from the solenoid efficiently, the mounting surface should not receive heat from any source other than the solenoid. If the mounting surface does receive heat from another source, this fact must be considered.

The importance of this fact was emphasized when a machinery manufacturer designed a rotary solenoid into a piece of equipment, planning to mount the solenoid to a metal surface. Under normal circumstances, this surface would provide good cooling. Solenoids were installed, but during initial tests their coils burned out. A check revealed that the solenoids were mounted directly to a diesel engine. A temperature rise was created not only by internal electrical heating but by the mounting surface itself. Hence, the mounting surface presented a negative effect.

Nature of the Load: The load characteristic should match the torque-output characteristic of the solenoid as closely as possible. Therefore, the nature of the load which will be applied to the solenoid is important.

Method of Applying Load: A number of design features are available to provide a means of power take-off for the solenoid load. These include shaft extensions at either or both ends of the solenoid for affixing a lever or rotary load directly to the shaft; pins in the armature plate providing

Factors To Consider in Applying Rotary Solenoids and Selectors

1. **Solenoids Only**
   a. Inertia or friction load.
   b. Variation in load factors at different points in the stroke.
   c. Type of mounting—heat dissipating or containing.
   d. Method of applying load.
   e. Return mechanism. Is return spring required or will driven mechanism return solenoid?
2. **Solenoids and Selectors**
   a. Variation in power-supply voltage.
   b. On-time to off-time ratio.
   c. Actual length of on-time.
   d. Amount of space available.
   e. Choice of leads or solder terminals.
   f. Environmental factors—temperature, salt spray, vibration, etc.
3. **Selectors Only**
   a. Complete circuit-switching data—number of contacts, sequence, etc.

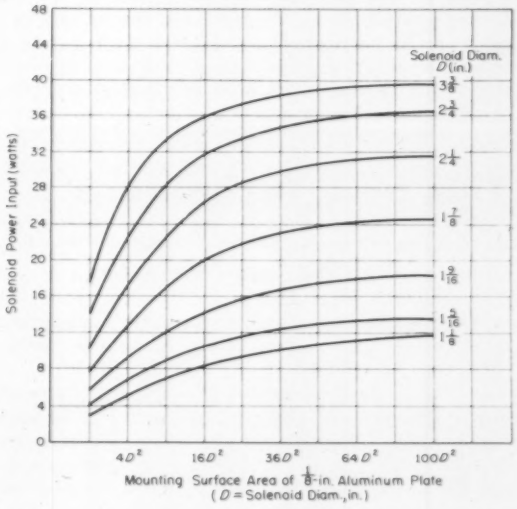


Fig. 5—Results of impressing sufficient wattage on various solenoids attached to $\frac{1}{8}$-in. aluminum plates to produce an 80 C temperature rise for continuous duty. Required mounting surface area is based on solenoid diameters. For example, a $2\frac{3}{4}$-in. diam solenoid with a power input of 36 watts requires a surface area of $(8D)^2$ or 484 sq in. to hold the temperature rise down to 80 C or less for continuous-duty operation.

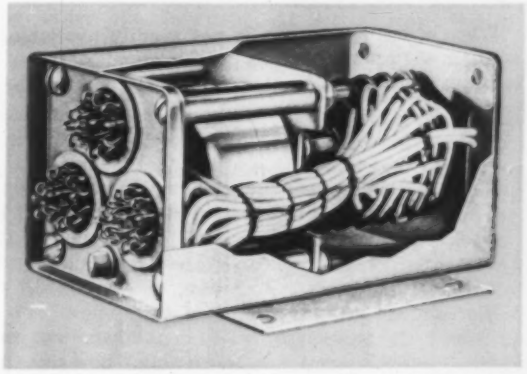


Fig. 6—Hermetically sealed rotary selector switch with a built-in rotary-solenoid drive. Standard hermetically sealed switches of this type are available with as many as five wafers and 105 pins in the header.

built-in lever action; tapped holes in the armature plate for attaching a load or linkages; and the ratchets, previously discussed. Many custom-engineered methods also can be provided.

In all applications, whether the load is attached by one of the above methods or by some special means, the axial movement of the shaft must not be restricted. Such a restriction would shorten the rotary stroke.

Operating Conditions: If adverse operating conditions, such as vibration and shock, are present in the application it is quite possible that special design features will be necessary.

In considering rotary selectors, it must be recognized that wafer-switch contacts in the unit shown in Fig. 3 have an approximate rating of 100 w. If more power is to be switched, the switch sections can be paralleled to divide the electrical load. Inductive loads require adequate spark suppression, so it is best to know if the load is inductive or resistive, and ac or dc.

Wafer-switch design also must be thoroughly considered if the proper switching arrangement is to be secured. The most efficient configuration will often eliminate contacts and even wafer sections.

When enclosed rotary selectors are required, the purpose of the enclosure will dictate its design. A variety of connector types are available for the transmission of a circuit from the inside of the enclosure to the exterior.

Standard designs of enclosed rotary selectors are recommended wherever possible, but special designs can be developed if there are space limitations or restrictions on the method of mounting the enclosure. Consider, too, specifications on external finishes of the enclosure. Environmental conditions could be detrimental, and these factors should not be overlooked.

Finally, if the unit is to be hermetically sealed, Fig. 6, do not overlook such specifications as leakage rate, type of filling gas, and pressure within the enclosed unit after sealing.

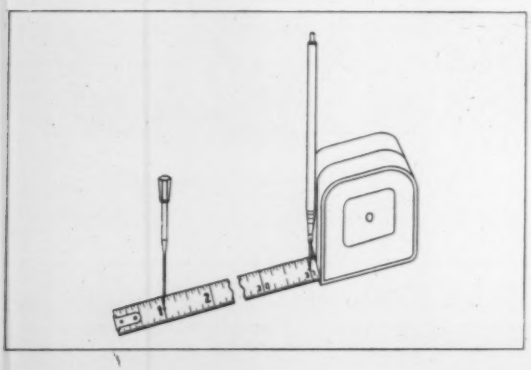
Tips and Techniques

Calculating Gear-Train Ratios

When setting up a gear train to obtain a given ratio, using only a few stock gears, calculation time can be reduced if the number of teeth on each gear is first expressed in completely factored form. The ratio of any pair of gears can be seen immediately by mentally cancelling all common factors. The product of several meshes can be quickly found in the same way. Thus, to find the ratio of a 108-tooth gear to one with 72 teeth, write $108 = 2 \times 2 \times 3 \times 3 \times 3$ and $72 = 2 \times 2 \times 2 \times 3 \times 3$. By mentally cancelling two 2's and two 3's, the ratio is found as 3/2.—JESSE ROTH, *New York, N. Y.*

Substitute for Beam Compass

When a beam compass is not readily available, or when the arc radius falls outside standard beam-compass limitations, a standard steel tape can be used. Simply punch a pair of holes, the desired radius apart, on the blade of the tape. Insert a steel scribe point through one hole and another scribe or sharp pencil through the other and swing the radius.—E. R. KASHUBA, *machine designer, Antenna Coupler Section, Remington Rand Univac Div. of Sperry Rand Corp., St. Paul, Minn.*



Thick-Walled Cylinder Stresses

Lame's formula for thick-walled cylinders is usually expressed in terms of the inner and outer radii of the cylinder. However, since ratios are involved, diameters may be used instead. Moreover, since the diameters are squared, it is possible to replace them by corresponding circular areas, directly in the formula. Tables of circular areas are readily available. In addition, the areas are required to calculate hydraulic forces, cubic contents and weights of material, so use of areas rather than radii makes sense.

The adjusted Lame's formula for internal pressure is

$$s = p\left(\frac{R^2 + r^2}{R^2 - r^2}\right) = p\left(\frac{A + a}{A - a}\right)$$

For external pressure the formula is

$$s = p\left(\frac{2R^2}{R^2 - r^2}\right) = p\left(\frac{2A}{A - a}\right)$$

Where $A = \pi R^2$, sq in.; $a = \pi r^2$ sq in.; p = hydraulic pressure, psi; R = outer radius, in.; r = inner radius, in.; and s = hoop stress, psi.—WILLIAM L. GOVAN, *Cooper Union, New York, N. Y.*

Catalog of

Equivalent Mechanisms for Cams

for simplified graphical analysis of complex cam-follower motions

By HAROLD A. ROTHBART
Associate Professor of Mechanical Engineering
The City College
New York, N. Y.

PRESENT-DAY design requirements usually dictate that machine components move in a prescribed, exact path. Connected members alone can rarely fulfill this requirement. It is therefore necessary to resort to the use of various contoured surfaces in the form of cams. Since the cam takes any shape, it is simple and adaptable.

By definition, a cam is a mechanical member for transmitting a desired motion to a follower by direct contact. The cam may remain stationary or translate, oscillate, or rotate, whereas the follower may translate or oscillate.

In low-speed, lightweight cam-follower systems, the design of the cam may be very simple, requiring little understanding of contours. As either mass, speed, or elasticity of the follower linkage increases, a detailed study must be made of the contour and its characteristic velocity and acceleration curves. Thus, pertinent information relating to cam size, vibration, dynamic loads, noise, wear, stresses, etc., is obtained.

Often, movement of the follower is difficult to establish analytically, especially if the follower is not of the radial translating type. Equations for the basic cam curves, such as simple harmonic, parabolic, cycloidal, polynomial, etc., have been extensively treated in the literature. However, these equations are all based on the radial translating follower and constant-speed, rotating radial and cylindrical cams. Other cams, having motion other than constant speed, and other followers are not included. This article presents a compilation of equivalent mechanisms to broaden the understanding and potential of the engineer in the analysis of such systems.

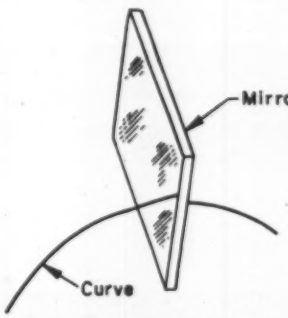


Fig. 1—Method of finding normal to any curve with a mirror or polished surface.

Basic Concepts: An equivalent mechanism may be defined as one which provides motion identical to that of a given member on the original mechanism. From a kinematic view, in its general form the plain cam mechanism consists of two shaped members that are connected by a fixed third body, A, as depicted in Table 1, Case 1. Either shaped member may be the cam in this arrangement with the other the follower. At any instant, these shaped bodies may be replaced by an equivalent quadric mechanism with members as shown in Case 1. These links are pin-jointed at the instantaneous centers of curvature, P and Q, of the contacting surfaces. At any other instant, with a new point of contact and a new equivalent mechanism, points P and Q are shifted and the links of the equivalent mechanism have different lengths. Since the equivalent mechanism changes during a cycle it is necessary to consider the action on an instantaneous basis.

The equivalent-mechanism method of analysis has two advantages. First, it permits the analysis of cams and followers of any form moving in any manner. (Later in this article, a simple graphical solution for follower acceleration will be shown, employing the conventional acceleration polygon in which the complete mechanism may be includ-

ed.) Second, it provides a pictorial concept of the relative movement of the members.

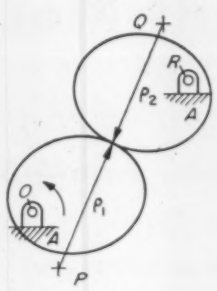
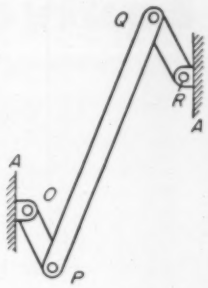
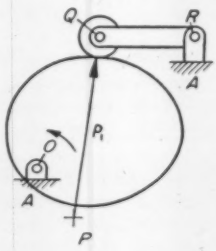
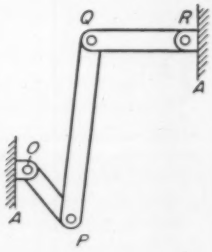
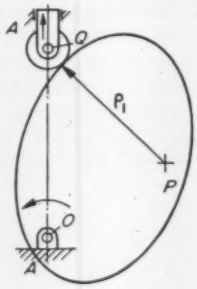
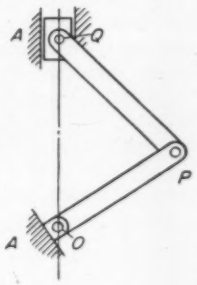
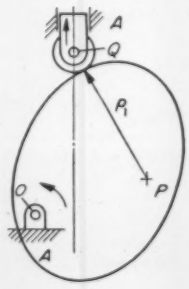
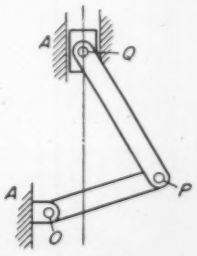
The method is applicable to any cam shape since the profile is considered as being composed of a series of small-length circular arcs. Thus, normal lines to the profile must be drawn to determine centers of curvature. These normal lines can be located by eye and drawn with a straightedge. However, accuracy can be increased greatly by the use of a thin reflecting surface, such as a mirror or a flat strip of polished steel, Fig. 1. The polished surface is placed at any point on the cam curve in such a position that the drawn curve lines up with the reflected image. The mirror edge is then normal to the curve at the given point and the normal line can be drawn. This procedure is repeated at another point on the cam profile a small distance away. The intersection of the normal lines locates the approximate center of curvature for that small increment of cam curve between them. Note that the accuracy of this method is usually sufficient for finding acceleration because of the inherent error existing in present methods of fabricating cam profiles.

Consider now the various equivalent mechanisms for a number of practical cam-follower systems, Table 1. In Cases 1 and 2, where a curved-faced oscillating follower is employed, the equivalents are quadric mechanisms. Cases 3, 4, and 5, with curved-faced translating followers, have slider-crank chains as equivalent mechanisms. For the 90-deg translating flat-faced follower, Case 6, the Scotch-Yoke mechanism is its equivalent, while for the oblique translating flat-faced follower, Case 7, it is the double-slider mechanism. Next are the oscillating flat-faced follower, Case 8, and the oscillating roller follower with a flat-sided cam, Case 9. Both have the same inversion of the slider-crank chain mechanism as equivalents. Similarly, flat-sided cams with translating-roller and curved-face followers, Cases 10 and 11, have the same equivalent crossed-slider chain mechanism. Cases 12 and 13 deal with the rare translating cams and followers, and their equivalents.

It should be noted in Cases 2, 3, 4, 6, 7, and 8 that, if the cam profile were composed of circular arcs, the same equivalent mechanism would apply for a specific portion of that profile. Also, if cam and follower profiles were both composed of circular arcs in Cases 1, 5, and 12, the same equivalent mechanism would apply for portions of both contacting arcs. A similar situation exists for eccentric-circle cams, giving a greater range of application for the equivalent mechanism without changing the proportions of its links. However, it should be remembered that cam profiles made up of combinations of circular arcs have a disadvantage in that abrupt changes in acceleration occur at the points of intersection of the arcs. This condition is obviously related to the differences between radii of curvature at these points. High speeds are generally prohibited.

Acceleration Polygon: For the different equiva-

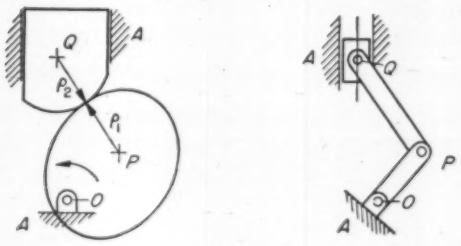
Table 1—

Cam-Follower System	Equivalent Mechanism
Case 1 - Generalized Cam Mechanism	
	
Case 2 - Oscillating Roller Follower	
	
Case 3 - Translating Radial Roller Follower	
	
Case 4 - Offset Roller Follower	
	

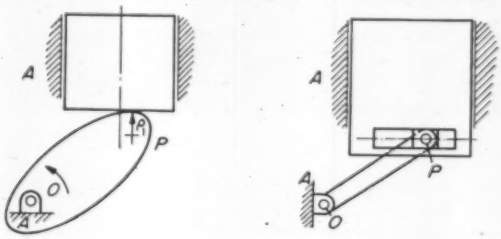
Equivalent Mechanisms

Cam-Follower System	Equivalent Mechanism

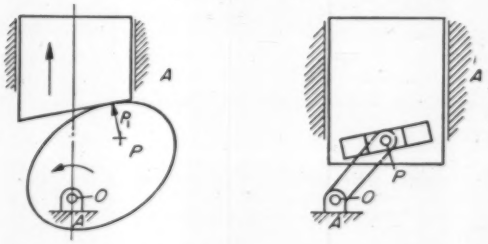
Case 5- Translating Curved-Faced Follower



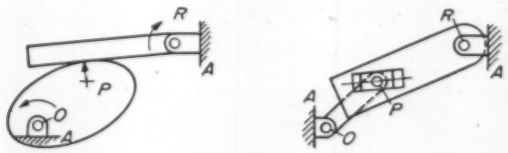
Case 6- Translating 90-degree Flat-Faced Follower



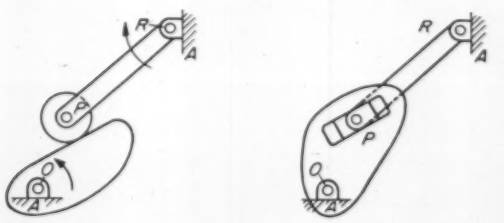
Case 7- Translating Oblique Flat-Faced Follower



Case 8- Ocillating Flat-Faced Follower

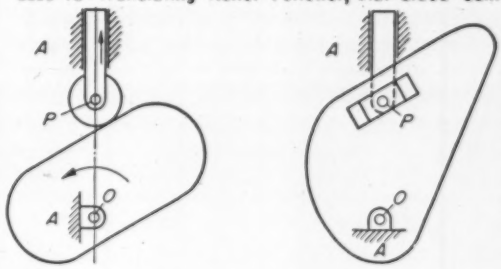


Case 9- Oscillating Roller Follower, Flat-Sided Cam

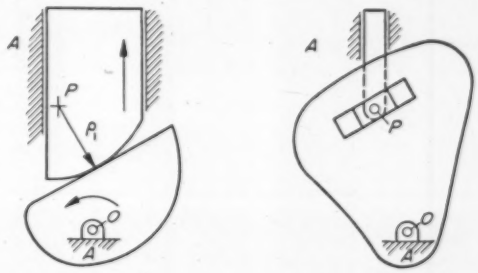


Cam-Follower System	Equivalent Mechanism

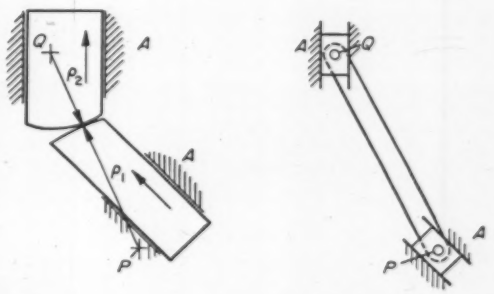
Case 10- Translating Roller Follower, Flat-Sided Cam



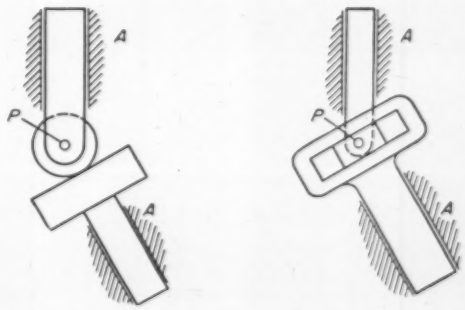
Case 11- Translating Curved-Faced Follower, Flat-Sided Cam



Case 12- Translating Curved-Faced Follower and Cam



Case 13- Translating Roller Follower, Flat-Faced Cam



lent mechanisms given in Table 1, we observe two types of connectors between links: 1. Turning pairs. 2. Sliding pairs in a translating path. We will now review the acceleration relationships for these conditions.

In Fig. 2*a*, points *P* and *Q* are located in body *B*. The acceleration of point *P* relative to point *Q* is composed of two perpendicular components in the directions shown. Normal acceleration ${}_{n}a_{PQ}$ is

$${}_{n}a_{PQ} = \overline{PQ}\,\omega_B^2$$

where $\overline{PQ}$ = distance from *P* to *Q*, in., and ω_B = instantaneous angular velocity of body *B* relative to the ground *A*, rad per sec. Direction of acceleration is from *P* to *Q*. To avoid uncertainty concerning the sense of normal acceleration, we should

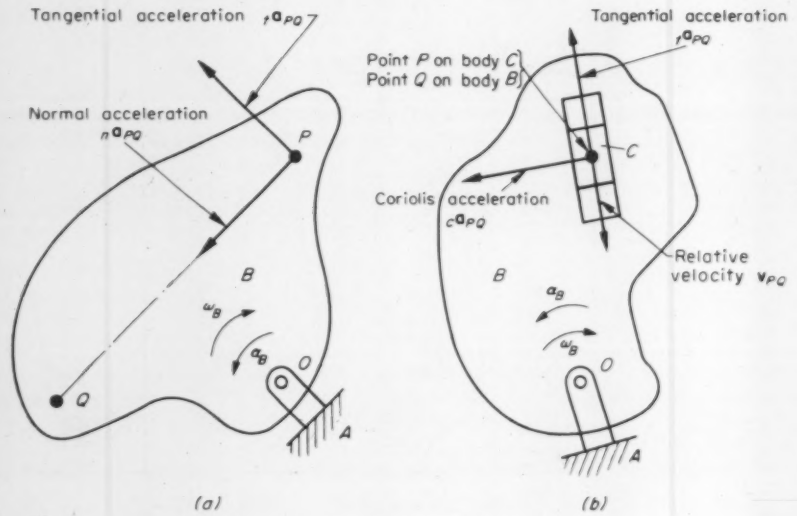


Fig. 2 — Analysis of general acceleration relationships for, *a*, turning pairs and, *b*, sliding pairs in a translating path.

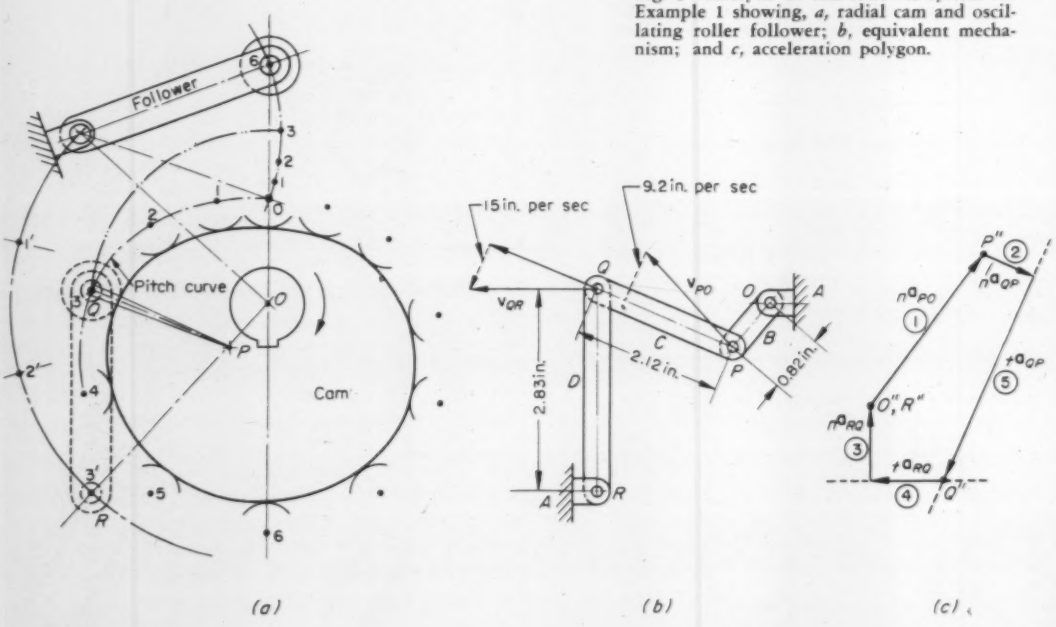


Fig. 3—Analysis of cam-follower system for Example 1 showing, *a*, radial cam and oscillating roller follower; *b*, equivalent mechanism; and *c*, acceleration polygon.

remember that any two points in the same rotating body always accelerate toward each other.

Tangential acceleration ${}_t a_{PQ}$ is

$${}_t a_{PQ} = \overline{PQ}\,\alpha_B$$

where α_B = instantaneous acceleration of body B relative to the ground A, rad per sec.^{2} Sense is in the tangential direction of the angular acceleration of body B.

In Fig. 2*b*, point P on the slider C is translating (driven elsewhere) with respect to point Q on body B with a velocity v_{PQ} shown. The acceleration of point P with respect to point Q is composed of two perpendicular components. The Coriolis component, ${}_c a_{PQ}$, is

$${}_c a_{PQ} = 2\, v_{PQ}\, \omega_B$$

in the direction that rotation of link B would turn the velocity vector $\mathbf{v}_{PQ}$, and the tangential acceleration vector, ${}_t\mathbf{a}_{PQ}$, 90 degrees, Fig. 2*b*. Thus, a Coriolis component of acceleration exists in a mechanism when a point on a link moves in a rotating path of another link. Coriolis acceleration components exist in Cases 8, 9, 10, and 11, Table 1.

To determine the acceleration of the links in a mechanism, we will add vectorially the acceleration of each point relative to the previous point in sequence, giving an end resultant equal to zero (the polygon closes).

Example 1: A radial cam turns at 400 rpm and has an oscillating roller follower, Fig. 3*a*. The total rise of the follower occurs in 180 deg of rotation. Find the instantaneous angular acceleration of the follower at position 3 in the diagram.

SOLUTION: The first step is to determine the center of curvature of position 3 by constructing normals to the pitch curve a small distance either side of the point. This establishes point P as the center of curvature. The equivalent mechanism is shown in Fig. 3*b*. Next, find the angular velocities of links B, C, and D. Angular velocity ω_B of link B is

$$\omega_B = 400 \left(\frac{2\pi}{60} \right) = 41.8 \text{ rad per sec}$$

Absolute velocity v_{PO} of point P is

$$v_{PO} = \overline{OP}\,\omega_B = 0.82(41.8) = 34.3 \text{ ips}$$

By the component method shown in Fig. 3*b*, the relative velocity, v_{PQ}, of point P with respect to point Q is

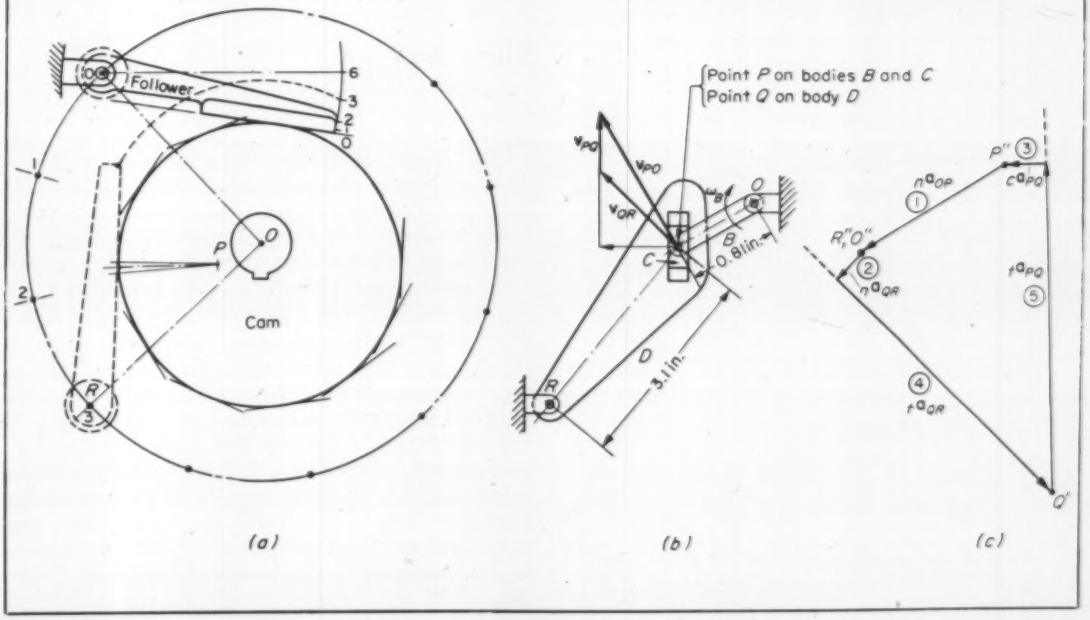
$$v_{PQ} = 15 + 9.2 = 24.2 \text{ ips}$$

Angular velocities ω_C and ω_D, of links C and D, respectively, are

$$\omega_C = \frac{v_{PQ}}{\overline{PQ}} = \frac{24.2}{2.12} = 11.4 \text{ rad per sec}$$

$$\omega_D = \frac{v_{QR}}{\overline{QR}} = \frac{36.2}{2.83} = 12.8 \text{ rad per sec}$$

Fig. 4—Analysis of cam-follower system for Example 2 showing, *a*, radial cam and oscillating flat-faced follower; *b*, equivalent mechanism; and, *c*, acceleration polygon.



Next, establish the acceleration relationships:

$$\mathbf{a}_{PO} + \mathbf{a}_{QP} + \mathbf{a}_{RQ} + \mathbf{a}_{OR} = 0$$

$${}_n\mathbf{a}_{PO} + {}_t\mathbf{a}_{PO} + {}_n\mathbf{a}_{QP} + {}_t\mathbf{a}_{QP} + {}_n\mathbf{a}_{RQ} + {}_t\mathbf{a}_{RQ} + 0 = 0$$

The known accelerations are

$${}_na_{PO} = \overline{PO}\,\omega_B^2 = 0.82(41.8)^2 = 1430 \text{ in. per sec}^2$$

$${}_ta_{PO} = 0 \text{ (constant speed cam)}$$

$${}_na_{QP} = \overline{QP}\,\omega_C^2 = 2.12(11.4)^2 = 275 \text{ in. per sec}^2$$

$${}_na_{RQ} = \overline{RQ}\,\omega_D^2 = 2.83(12.8)^2 = 465 \text{ in. per sec}^2$$

Unknowns are ${}_ta_{QP}$ and ${}_ta_{RQ}$.

Now, construct the acceleration polygon shown in Fig. 3*c*, starting with a polar diagram which represents the directions and values of the vectors. Prime notations indicate the corresponding points of the mechanism on the polygon. Fixed points O and R have no acceleration and are located at O'', R'' on the drawing. Then, construct ${}_n\mathbf{a}_{PO}$, locating the end of the acceleration vector of point P at P''. Normal accelerations ${}_n\mathbf{a}_{QP}$ and ${}_n\mathbf{a}_{RQ}$ are constructed and the tangential component directions are drawn. The intersection of these lines locates Q''. Thus, we have the instantaneous accelerations of the complete mechanism at this position. Angular acceleration α_D of the follower is

$$\alpha_D = \frac{{}_ta_{RQ}}{\overline{RQ}} = \frac{540}{2.83} = 190 \text{ rad per sec}^2$$

Direction of α_D is clockwise.

Example 2: A radial cam rotates at 400 rpm and has an oscillating flat-faced follower, Fig. 4*a*. Determine the follower angular acceleration at position 3.

SOLUTION: As before, establish the equivalent mechanism in Fig. 4*b*. The following velocities are obtained:

$$\omega_B = 400\left(\frac{2\pi}{60}\right) = 41.8 \text{ rad per sec}$$

$$v_{PO} = \overline{OP}\,\omega_B = 33.8 \text{ ips}$$

$$v_{QR} = 20 \text{ ips (Fig. 4}b\text{)}$$

$$v_{PQ} = 16 \text{ ips (Fig. 4}b\text{)}$$

$$\omega_D = \frac{v_{QR}}{\overline{QR}} = \frac{20}{3.10} = 6.47 \text{ rad per sec}$$

Direction of ω_D is counterclockwise. The acceleration relationships are:

$$\mathbf{a}_{QR} + \mathbf{a}_{PQ} + {}_c\mathbf{a}_{PQ} + \mathbf{a}_{OP} + \mathbf{a}_{RO} = 0$$

$${}_n\mathbf{a}_{QR} + {}_t\mathbf{a}_{QR} + {}_n\mathbf{a}_{PQ} + {}_t\mathbf{a}_{PQ} + {}_c\mathbf{a}_{PQ} + {}_n\mathbf{a}_{OP} + {}_t\mathbf{a}_{OP} + 0 = 0$$

Known accelerations are:

$${}_na_{PQ} = 0$$

$${}_ta_{OP} = 0$$

$${}_na_{QR} = \overline{QR}\,\omega_D^2 = 3.10(6.47)^2 = 129 \text{ in. per sec}^2$$

$${}_ca_{PQ} = 2v_{PQ}\omega_D = 2(16)(6.47) = 206 \text{ in. per sec}^2$$

$${}_na_{OP} = \overline{OP}\,\omega_B^2 = 0.81(41.8)^2 = 1410 \text{ in. per sec}^2$$

Unknowns are ${}_ta_{QR}$ and ${}_ta_{PQ}$.

Then, construct the acceleration polygon, Fig. 4*c*, in the numbered sequence in which the intersection between the foregoing unknown tangential acceleration vectors locates the point Q'' and the polygon is closed. Instantaneous angular acceleration of the follower at this position is:

$$\alpha_D = \frac{{}_ta_{QR}}{\overline{QR}} = \frac{2120}{3.10} = 684 \text{ rad per sec}^2$$

Direction of α_D is clockwise.

Summary: Thus we have seen that equivalent mechanisms provide a concept of motion and a simplified means for determining follower acceleration. Of course, caution is necessary in establishing the radius of curvature of the cam at the point under consideration. It is furthermore suggested in designing the cam that first one of the basic curves such as cycloidal, parabolic, trapezoidal, etc. be employed. In this way, the analysis shown will indicate good dynamic follower characteristics.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and *Machine Design*.

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2. J. H. Billings—*Applied Kinematics, Third Edition*, D. Van Nostrand Co., 1953.

They Say . . .

"We should give more thought to the employment of women in engineering. Because we cannot readily imagine women engineers in say shipyards we should not ignore the possibilities of using them in other types of industry, in drafting rooms or research laboratories and many other roles."—SIR GEORGE H. NELSON, *president, Institute of Electrical Engineers.*

"Lack of effective communication—and failure to take intelligent, decisive action based on clear understanding—causes the failure of many worthwhile projects, and increases the gross cost of development work by a factor of at least two, and possibly more."—MORROUGH P. O'BRIEN, *dean, College of Engineering, University of California, Berkeley, Calif.*

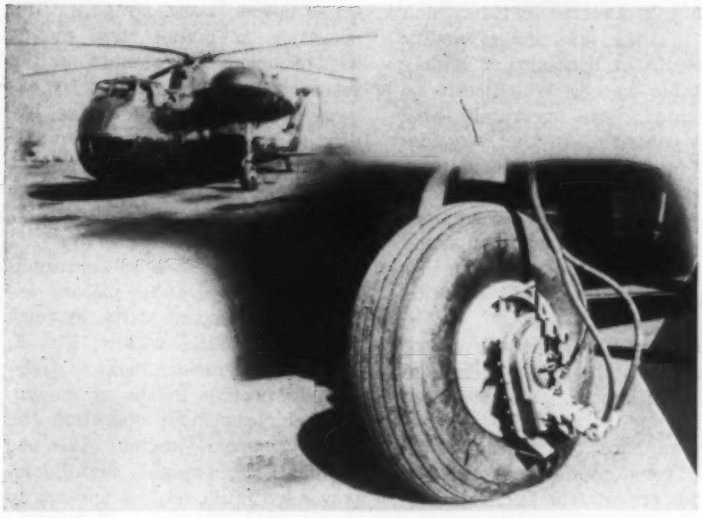

Fig. 1—A newer applications for hydraulic motors. Vehicles which require movement without operation of main propulsion units can be equipped with individual, lightweight hydraulic motors on each wheel. These motors are applicable to vehicles and other units such as heavy test stands and mooring rigs which require towing at present.

What Hydraulics Can Do

By FRANK L. MONCHER
Director of Engineering
Aero Hydraulics Div.
Vickers, Inc.
Detroit, Mich.

THE following characteristics of hydraulic components and systems should be considered when planning to use hydraulics in power systems:

1. Weight and size of hydraulic units and transmission lines involved are very low. These should be computed and compared with those of other transmission means. Although it is difficult to generalize, hydraulics will appear more favorable as horsepower transmitted increases. The small size and lightweight of hydraulic components for high-power application permit integration and packaging.

2. Efficiency of transmitting energy is high, which results in less power required from the prime mover and considerably less power loss to be dissipated in heat.

3. Torque-to-inertia ratios for hydraulic actuators are extremely high, which means exceptional control characteristics from the standpoint of dynamic response and accuracy. This is particularly important in the design of servomechanisms and controllable - speed drives.

4. Available high pressures accentuate the desirable characteristics of fast response and, in addition, beneficial side effects such as compactness and tightness of the system accrue.

5. Control of pressure and flow for the power-generation device can be achieved by various means to acquire desirable characteristics. An outcome of this feature is that control of output speed for variable-speed transmissions is stepless and smooth throughout extreme speed ranges.

6. The same hydraulic unit can be used to convert energy in either direction, i.e., from mechanical to hydraulic (pump) or from hydraulic to mechanical (motor) with no penalty in unit weight or size. This reversible transducer principle is also utilized in constant-speed drives and servo systems.

7. Actuator torque is a function of pressure which can be readily controlled, and torque output remains essentially constant regardless of speed to a maximum speed condition or to a complete stall condition. Thus, an external torque can be balanced and held indefinitely without heat generation due to continuous power losses.

8. By means of servo valves or servo pumps, tremendous power amplification per stage can be achieved with simple, rugged components.

9. Inherent good speed and torque regulation of hydraulic components mean that torque configurations can be simple and straightforward and of low power-requirements.

10. When properly designed, hydraulic units are compatible with wide variations in ambient conditions. Extreme temperature ranges, from −65 to 400 F, are presently permissible with reliable operation. Performance can be maintained under various conditions of vibra-

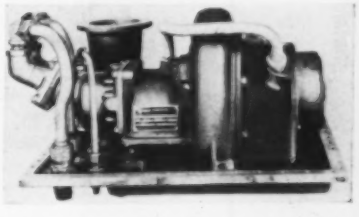

Fig. 2—Immersible-type hydraulic motor. The small size, high horsepower-to-weight ratio, and explosionproof construction of hydraulic motors make them suitable for applications which require transfer of fluids without contamination.

tion, shock, salt spray, humidity, etc., because of the inherent hermetically-sealed nature of the hydraulic units.

Examples of applications in which consideration of these characteristics has led to selection of hydraulics will be discussed. This discussion touches briefly on present applications and stresses newer uses to which hydraulics have been put, Fig. 1, or have been proposed for use in the future.

Supercharger Drives: Hydraulic transmissions are well-suited to application as supercharger drives which require infinitely variable transmission ratios because of high over-all efficiency and flexibility of control that can be obtained. Both the split-torque type and the conventional full-torque hydraulic transmission types are applicable. Because of high volumetric efficiency of hydraulic motors, output speed does not vary greatly when load changes, thereby reducing demands on the speed-control equipment. Also, low rotary-inertia makes it possible to achieve high dynamic performance. These factors result in maximum acceleration and minimum change in output speed for variations in prime-mover speed or load changes.

Fuel Boost and Transfer Pumps: Hydraulic motors are good choices for driving fuel pumps because of extremely small size, high horsepower-to-weight ratio, and hermetically sealed, explosionproof construction. They can be immersed in a fuel tank with complete safety and without contaminating the fuel, Fig. 2. Another feature which leads to their selection is ability to operate at constant or widely adjustable speeds which can be maintained quite accurately with simple controls. In this way, delivery of fluid from various tanks can be made in equal volumes or maintained at desired proportions to each other automatically and without complicated control devices by proper circuitry and selection of motor sizes.

Ability of the hydraulic motor to maintain stall or slow-speed conditions without appreciable heat losses is particularly advantageous in these applications, since fuel demands vary greatly. When fuel demands are low, the hydraulic motor operates at the required speed without dissipating excessive power. This low heat-rejection and lack of hot spots minimize temperature rise of the fuel in tanks and when passing through the pump.

Hydraulic Boost-Pumps: In applications where boost is required for hydraulic fluid to main pumps, a boot-strap scheme is used wherein a small percentage of high-pressure fluid is diverted to a hydraulic motor which drives a boost pump. This arrangement has high efficiency, and the simple, reliable circuit requires a minimum of control complexity. Complex flow-control valves are not needed, since the motor-pump combination can be designed to generate proper boost pressure at needed flow, or to stall without damage or appreciable power losses. By permitting operation of main-system pumps with atmospheric pressure on the reservoir, problems caused by excessive back pressure in the hydraulic brake-circuit are eliminated. Also, higher boost pressures permit use of smaller inlet lines to main-system pumps.

Wheel Drives: A newer application for hydraulic motors involves independent drive systems for heavy-vehicle wheels, Fig. 1. Many considerations make it desirable to provide means of moving the vehicle without operating the main propulsion engine. The use of small, lightweight, high-horsepower hydraulic motors appears to be an ideal solution to this problem.

To provide hydraulic power required during operation without running the main engine, a compact, self-contained hydraulic power unit is available. In addition to providing power for moving, this power unit can also supply hydraulic power for auxiliary drives.

Engine Starting: An application for which extensive plans and actual development work are underway at the present time, is that of starting jet engines. Here, use of hydraulic power means considerable weight and power reduction. A present system provides starts within 27 to 30 sec, and the starter motor weighs approximately 22 lb.

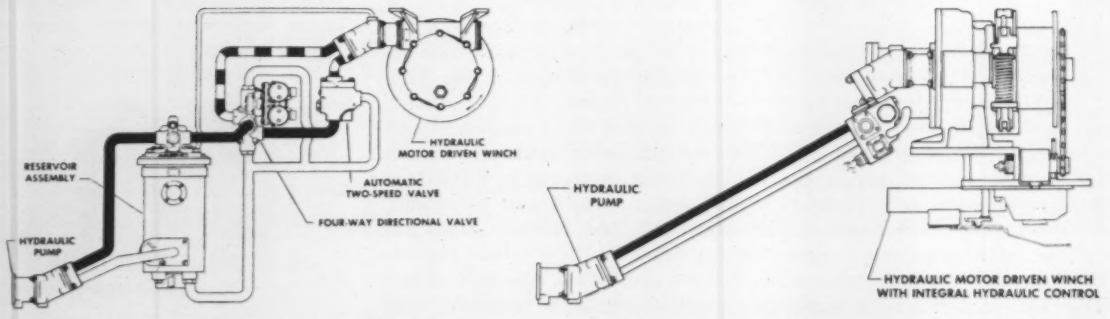

Fig. 3—Left—Original hoist design before packaging. Right—New design incorporates all components of the old one except the hydraulic pump. Package includes automatic mechanical brake which locks the winch drum when hydraulic power is cut off, emergency cable-cutters, playout and reel-in controls, and winch drum. The new design presents a simple bolt-on installation which weighs only 70 lb and has only two connections. The new design also increased capacity by 200 lb.

The hydraulic motor is well-suited for this application, since it is capable of generating maximum torque at all speeds. Necessary components are contained within a package so that minimum connections are required.

Winches and Hoists: An original hoist design, Fig. 3, left, consisted of an engine-driven pump, reservoir, control valves, hydraulic motor, and winch drum. A new design, Fig. 3, right, which is a completely packaged unit, contains all items except the hydraulic pump in one convenient assembly. This package includes a level - wind mechanism, automatic mechanical brake; electrically actuated, cartridge operated, emergency cable cutter; built in play-out and reel-in limit controls; automatic anti-overrun controls in addition to the hydraulic motor; reduction gearing; and the winch drum. Incorporating all items in this manner provides a simple bolt-on installation with only two connections to the general hydraulic system. Although this winch was designed for helicopters, it can be utilized in other vehicles. Capacity is approximately 600 lb. Its weight is 70 lb, including pump and mounting, and lifting rate is slightly over 2 fps with approximately 250 feet of stainless steel cable available.

From a paper entitled "What Hydraulics Can Do," presented at Vickers' 7th Hydraulics Conference in Detroit, November, 1957.

Materials and design requirements for

High-Temperature ..... Hydraulics *Systems .....*

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THE upper operating-temperature limit of hydraulic systems is determined primarily by organic materials in the system. Organic materials are used as hydraulic fluids, elastomeric seals, antiextrusion rings, and electrical insulation. No precise upper-temperature limit can be established for any of these. In general, however, usable life of the organics diminishes rapidly as operating temperature increases. Above 600 F, organic materials have practically no significant operating life.

The limit imposed by organic materials means that, for environmental temperatures in excess of 600 F, system and component cooling must be employed to achieve significant operating life. In environmental temperatures below 600 F, cooling may or may not have to be employed, depending upon environmental compatibility of the system. Here is the area in which hydraulic systems may be optimized by designing for thermal compatibility.

Organic Materials: No amount of ingenuity in mechanical or electrical design is of value unless materials of construction and operation represent the best available. In a hydraulic system, power-transmission fluid is the most important material. It must be thermally stable at its operating temperatures, and moderate quantities of oxygen must not decompose it at these temperatures. It must be neither toxic nor irritant. Fluid should have a high-viscosity index and a low specific gravity. Bulk modulus should be very high and should remain high over the whole operating range. The fluid should also be hydrolytically stable, nondeposit-forming, resistant to entrainment of gases, be little affected by nuclear radiation, be noncorrosive, and fire resistant. Above all else, it should lubricate.

On the basis of these and one other requirement, industry and the services have chosen silicate-ester based fluids for use to 400 F. These fluids have many of the necessary properties but they do, however, require special handling to avoid water contamination. They are not particularly resistant to foam forming or nuclear bombardment. Their viscosity indexes are low compared, for instance, to the

dimethyl silicones, and their bulk modulus drops sharply as temperature rises.

The other requirement when silicate-ester fluids are chosen is elastomer compatibility. It may very well be that the advent of fluoroelastomers or the use of metallic seals might allow choice of other fluids. In this case, the dibasic-acid esters, the polyglycolethers, and heavy hydrocarbons represent fluid classes which warrant a careful second look.

Fluorination seems to be the popular solution to problems of other organic materials. Fluorinated elastomers for O-ring seals are available, and Teflon, virgin or with various inorganic loadings, is used for antiextrusion washers.

Electrically operated hydraulic devices are so intimately tied to the systems that their electrical problems must be considered as part of the hydraulic problem. Teflon, again, has been the high-temperature panacea for electrical insulation needs. However, this is an area where inorganic materials are gaining some recognition. Glass wrappings and anodized-aluminum coatings have been used with considerable success for high-temperature electrical insulation.

Metals: Metallic materials for high-temperature hydraulic components are used as structural and dynamic elements. As structural elements, the primary metallurgical consideration is strength-weight ratio. Typical aircraft steels have better strength-weight ratios than wrought-aluminum alloys at temperatures in excess of 275 F. However, designing purely to the strength-weight ratio at 275 F can yield sections which are too compliant. Depending on structural and usage requirements, 300 F is probably a more reasonable breaking point in the choice between aluminum and steel alloys.

Metallic materials for dynamic elements must be chosen with extreme care. Load-carrying compliant members tend to fail in creep when subjected to elevated temperatures. However, creep resistance and low allowable tensile-loads seem to go hand in hand. Proper design for creep then results in large, soft springs, for example, which must be protected in a vibrational environment and which tend to occupy too much space.

System Design: The most important consideration in designing a hydraulic system is that of minimizing internal heat generation. Wherever possible, variable-delivery pumps should be used. Pump by-pass lines should be as short as possible. Surge-producing areas should be protected by accumulators or large lines to minimize amount of oil forced through relief valves. Control valves of all sorts should be designed for the smallest amount of leakage consistent with proper operation. Distribution lines should be as large in diameter and as short in length as possible. Installation layouts should be studied carefully to reduce the number of bends and fittings to a minimum.

Design and choice of accumulators for high-temperature systems require more than ordinary care. Unless operating temperatures are taken into account, expansion of accumulator gases at operating temperature will force oil out of the accumulator and through the relief valve, thereby generating heat.

Reservoir design must account for oil expansion. Silicate-ester fluids expand about 5 per cent in volume for every 100 F rise. Unless provisions are made for this expansion, the reservoir will be overpressurized or fluid will be lost.

Because oxygen readily attacks most organics at high temperatures, the system must be completely closed. An airless, pressurized reservoir must be used.

From a paper entitled "Optimizing The Hydraulic System Through High Temperature Compatibility," presented at the Vickers' 7th Annual Aircraft Hydraulics Conference in Detroit, Michigan, Novemember, 1957.

Selection Criteria for Teflon Lubricating Films

MANY of the difficulties associated with using thin Teflon films as lubricants stem from a misunderstanding of the limitations of Teflon imposed by its softness, coating porosity, and heat-transfer problems.

Teflon's low-friction characteristic does not make it a cure-all for all lubrication problems nor does its chemical inertness make it the best protection for metals. Selection of Teflon for dry-film lubrication should be based on the unique combination of properties offered. Corrosion preventive attributes should then be considered.

Equipment or mechanisms lubricated with Teflon films must satisfy one or more of the following conditions:

1. They should provide compatible speed and load combinations, i.e., low surface sliding speeds with light to moderate loads, or high surface sliding speeds with high loads.
2. They should utilize coolants such as water, oil, or air blast.
3. Lubricated parts should have short-term use before overhaul.

The high coefficient of friction of Teflon at high sliding speeds indicates a new limitation to the use of bulk Teflon as a lubricating solid. It would be valuable for the designer who is considering Teflon as a lubricating material to know the maximum permissible conditions of lineal rubbing speed and bearing load. Where Teflon is used as a thin coating on a hard metal backing, this problem is especially important. The necessary criteria do not appear simple, for they depend greatly on the design of the system, on the thickness of the Teflon coating, and on the thermal conductivity and geometry of the metal substrate.

From a report entitled "Thin Films of Polytetrafluoroethylene Resin (Teflon) as Lubricants and Preservative Coatings for Metals," by V. G. FitzSimmons and W. A. Zisman. Available as OTS Research Report PB 121161, *from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.*

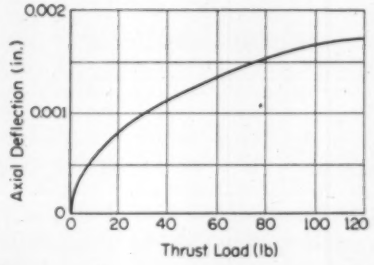
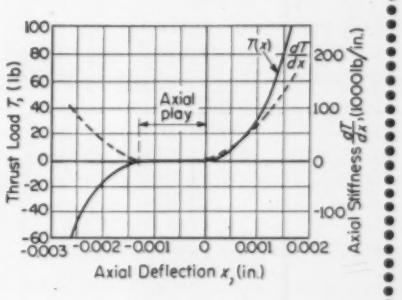


Fig. 1—Axial yield of a single bearing. Duplex-bearing analysis is simplified by plotting axial displacement values of bearing races along the abscissa and corresponding load values along the ordinate.

Fig. 2—Bearing deflection of one bearing of a duplex assembly before preloading. $T(x)$ represents deflection of left bearing of assembly of Fig. 3.



How to measure

Ball-Bearing Preload

By CLAUDE L. EMMERICH
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White Plains, N. Y.

THE basic function of a bearing is to maintain radial and axial alignment between machine elements without interfering with rotary motion. In certain applications, large radial or axial stiffness is required while friction torque about the bearing axis must be exceedingly small. These specifications are approximated in practice with preloaded ball or roller bearing pairs known as "duplex bearings."

Since stiffness and friction of a duplex-bearing assembly increases with preload, design of a duplex-bearing application represents a compromise between conflicting demands. Heavy preloads result in great stiffness at the expense of severe friction losses or even damage to bearing surfaces, whereas a light preload may not produce required stiffness of the bearing assembly.

In most cases, preload varies drastically as a function of temperature, clearances, bearing dimensions, and alignment, so that actual preload in a particular assembly may differ considerably from design value. A direct measure of operating preload of an assembled bearing pair is obtained by a friction determination or by a displacement measurement.

Friction Measurements: Resistance to rotary motion of a bearing depends on surface condition, lubrication, presence of foreign materials, and loads carried by the bearing. Assuming that all factors except loading remain unaltered, it is possible to deduce actual bearing preload from friction measurements made before and after the bearings are assembled.

With many factors besides load contributing to bearing friction, deduction of preload from friction measurements is not a reliable determination. This is particularly true if a long time interval has elapsed between pilot measurements and determination of actual preload, or if there are reasons to suspect a change in general friction characteristics. Nevertheless, friction measurement is practical because it is easily obtainable in many cases.

Prior to final assembly of the pair, each bearing is loaded individually, and the friction measurement is made by determining coast-down time of a mass supported by the bearing.

This measurement is repeated after the duplex bearings have been assembled. Assuming that friction torque is directly proportional to the load on each bearing, preload of the assembled pair can then be calculated.

For example, a single bearing supporting a 1-lb weight might exhibit a friction torque of 0.02 oz-in. Assume that two such bearings are assembled as a duplex pair with a design preload of 1.5 lb. Since each bearing contributes a friction torque corresponding to a thrust load of 1.5 lb, friction torque of the assembly should be 2 × 1.5 × 0.02, or 0.06 oz-in. If actual friction torque is only 0.04 oz-in., the bearings are operating with a 1-lb preload.

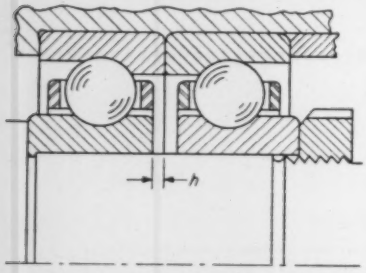

Fig. 3—Duplex bearings before preloading. Constant h is a value associated with initial separation of the bearings. Deflection of the right bearing becomes $-T(2h-x)$.

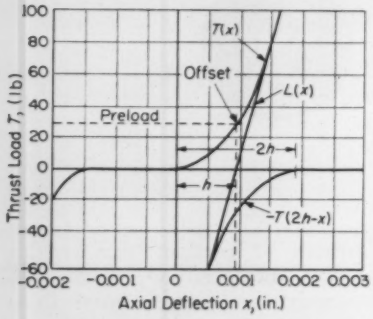

Fig. 4—Bearing deflection curves of $T(x)$ and $-T(2h-x)$. The slope of $L(x)$ is twice the slope of the deflection curve of a single bearing.

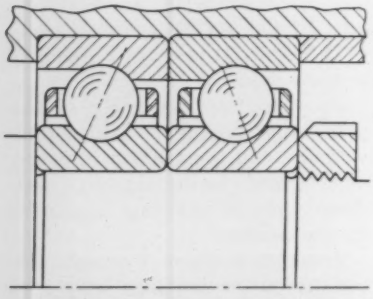

Fig. 5—Duplex bearings after preloading. Tightening assembly causes equal preloading and displacement of bearings in opposite directions.

Displacement Measurements: The primary purpose of preloading a bearing pair is to control displacements of members supported by the bearings as external loads are applied. Direct measurement of these displacements is a preferred method for determining preloads, although bearing deflections as a function of load are normally very small and accurate measurements are difficult to execute.

Bearing deflections caused by loading are plotted as yield curves with load as independent variable, Fig. 1. Analysis of the action of a preloaded pair of duplex bearings is simpler if axial displacement of the bearing races with respect to each other is plotted as the abscissa, and the corresponding load as ordinate. In Fig. 2, the deflection curve is extended to include negative forces, showing the axial play of the bearing and has the desirable property that its derivatives remain finite.

If two bearings are assembled as shown in Fig. 3, and $T(x)$ of Fig. 2 is taken as the deflection curve of the left bearing, then the deflection curve of the right bearing is $-T(2h - x)$, where h is a constant associated with the initial separation of the bearings. Both $T(x)$ and $-T(2h - x)$ are plotted in Fig. 4. Distance h is defined as the "offset" of each bearing.

Tightening the bearing assembly until the inner races touch, as shown in Fig. 5, causes both bearings to be loaded by the same amount in opposite directions and to be displaced by equal amounts in opposite directions. Stiffness of the bearing pair is twice the stiffness of a single bearing. Hence, actual preload of an assembled duplex-bearing pair is found by locating on the single-bearing deflection curve, such as Fig. 2, the point which has one-half the slope of $L(x)$, Fig. 4, the deflection curve of the assembled pair.

From a paper entitled "Measuring the Preload of Ball or Roller Bearings," presented at the ASME Annual Meeting in New York, December, 1957.

Temperature Ratings of Motor Insulation

A NEW edition of AIEE No. 1, "General Principles Upon Which Temperature Limits Are Based in the Rating of Electrical Equipment," introduces a new concept which permits greater freedom in selecting insulating materials and temperature limits best suited to individual applications. Classifications are now based on results of actual thermal evaluation tests instead of on composition or grouping of certain materials.

The new version of the definitions for various class groupings are:

CLASS O — 90 C — Materials or combinations of materials such as cotton, silk, and paper without impregnation.

CLASS A — 105 C — Materials or combinations of materials such as cotton, silk, and paper suitably impregnated or coated or immersed in a dielectric liquid.

CLASS B — 130 C — Materials or combinations of materials such as mica, glass fiber, asbestos, etc. with suitable bonding substances.

CLASS F — 155 C — Materials or combinations of materials such as mica, glass fiber, asbestos, etc. with suitable bonding substances.

CLASS H — 180 C — Materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, etc. with suitable bonding substances such as appropriate silicone resins.

CLASS C — Over 220 C — Insulation consisting entirely of mica, porcelain, glass, quartz, and similar inorganic materials.

Other materials or combinations of materials, not necessarily inorganic, may be included in any of the various classes if, by experience or accepted tests, they can be shown to be capable of operation at that particular class temperature limit.

From "Why Temperature Ratings On Motors," presented in the Bodine Motorgram, *Vol.* 37, *No.* 6.

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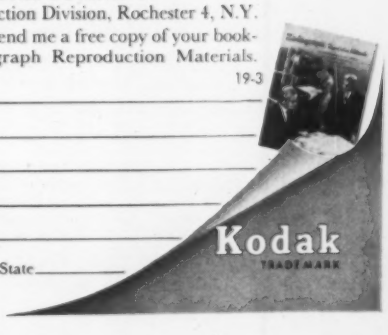

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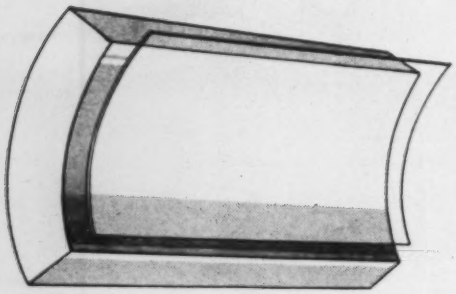


Dry Film Lubrication

By ROBERT L. JOHNSON
Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio

Solid lubricants, as bonded films or in dispersions, have considerable potential at extreme temperatures and under high surface stresses.

FEW LIQUIDS or greases may be used at temperatures as high as 450 F for any appreciable period of time while most solid lubricants are useful at 600 F or higher. The most successful use of solid lubricants has been in resin-bonded films. Other methods of utilizing solid lubricants are available but each has specific limitations in applications.

Solid-Film Theory: Friction coefficient is defined as the ratio of friction force to normal load. Friction force is a combination of a shear and a plowing term which is negligible for a thin film on a hard base-metal.

Important fundamental variables in a friction-coefficient equation are shear strength of the film material and base metal, and flow pressure, or yield strength in compression, of the softer of the two mating metal surfaces. The fraction of the total shear area over which metallic contact occurs and the portion of the total shear area in which the solid lubricant is sheared are primary factors which are used to interpret many observations.

In the absence of metal to metal contact, the ratio of film shear strength to yield strength in compression determines the coefficient of friction. With very thin films, this relationship is valid. As film thickness is increased, however, the solid lubricant may behave as a plastic, and the shear area is increased by junction growth which may be independent of the properties of the base metal. Thus, by changing film thickness, friction may vary appreciably.

Potential Solid Lubricants: A number of solids have been studied as potential solid lubricants, Table 1. Most of these promising materials have a layer-lattice crystal structure which provides potential easy-shear planes and are subject to beneficial orientation effects. Not all layer-lattice compounds are good lubricants, however, and some compounds which have other types of structures (such as silver iodide, AgI) provide effective lubrication. Inadequacy of crystal structure as a guide in the selection of solid lubricants is apparent when results for some completely isomorphous compounds are compared. Silver sulfate (Ag_2SO_4), for example, is an effective lubricant, but sodium sulfate (Na_2SO_4), which has the identical type of structure, fails to lubricate.

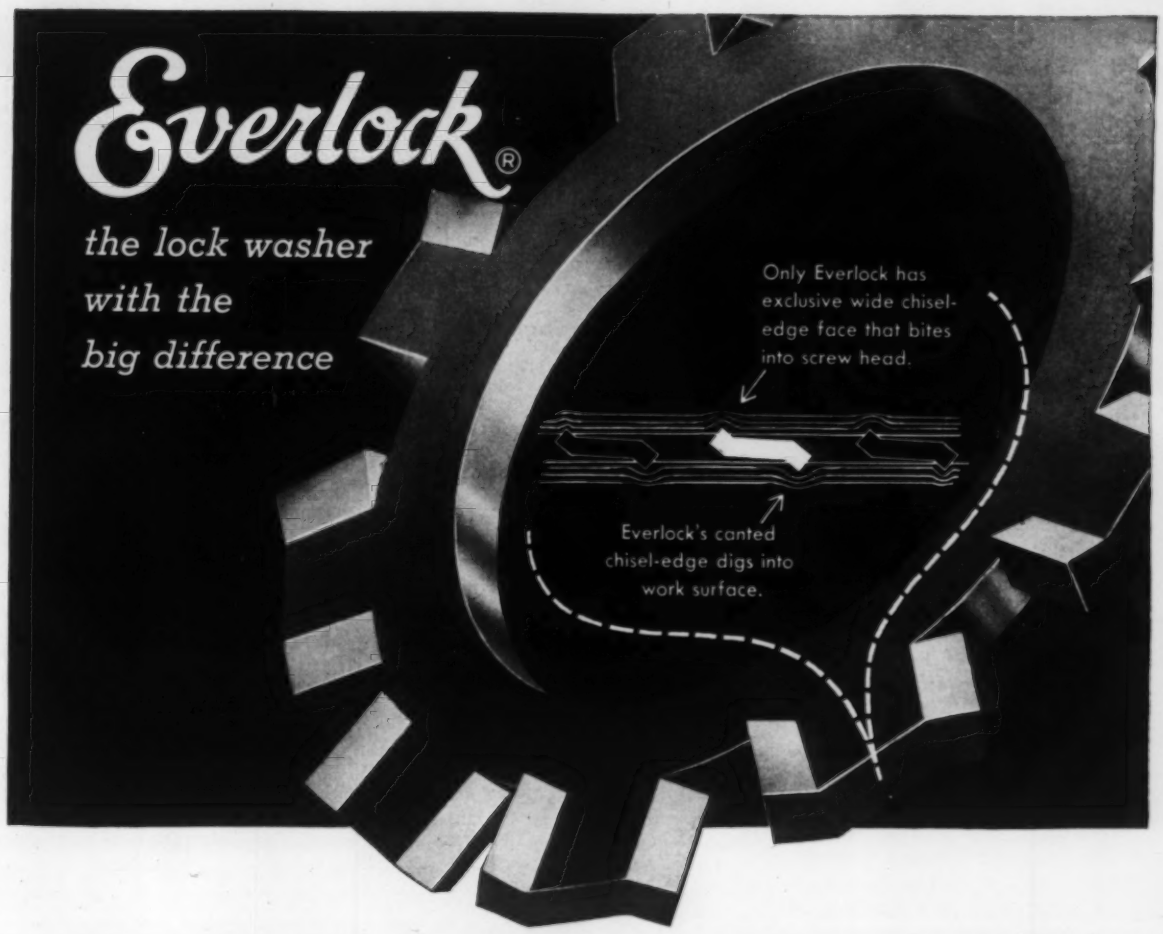
Effectiveness of solids as lubricants can be attributed more to formation of adherent films on lubricated surfaces than to any particular structural type. Boron nitride (BN) has a highly desirable structure but does not lubricate. It may become useful in solid molded bodies but in powdered form it appears to have little potential as a solid lubricant because it lacks ability to adhere to metal surfaces at temperatures to 1300 F in air. Moisture has little effect on lubrication with boron nitride.

Graphite is probably more widely known as a lubricant than any other solid material. However, it requires the presence of moisture before it can be an effective lubricant. Graphite will lubricate Inconel at 1000 F and at room temperature but not at all intermediate

Table 1—Characteristics of Dry-Film Lubricants

Materials	Friction Coefficient*	Action
MoS_2	0.06	Oxidizes above 750 F
CdI_2	0.06	Absorbs moisture
WS_2	0.08	Similar to MoS_2
Ag_2SO_4	0.14	Forms thick films
Na_2SO_4	0.41+	Does not lubricate
PbI_2	0.28	Good film formation
Graphite	0.06 to 0.10	No lubrication in dry air
PbO	0.23	Good at 1000 F
BN	0.41+	Does not lubricate
Teflon	0.06	Excellent below 550 F
AgI	0.19	Good film formation

*At 75 F and 40-lb load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temperatures. Addition of a supplementary oxide allows graphite to lubricate over the entire temperature range. The oxide is believed to contribute to the adherence of graphite to metals. Graphite also lubricates metal surfaces at progressively lower temperatures when more easily oxidized alloys are used. At 1000 F, graphite does not lubricate Inconel in the presence of a reducing atmosphere but it does lubricate Inconel in an atmosphere of either dry or moist air. However, these effects are completely reversible.

Problems in brush wear in electrical equipment, for example, have direct correlation with the lubrication phenomena discussed for graphitic carbon. In either case, adherent lubricating films on mating metal surfaces are essential to prevent excessive wear and to give acceptable friction. When adherent graphite films are established on mating metal surfaces, such as copper commutators, wear of carbon bodies is low. In the absence of such films, prohibitive wear is experienced. Molded graphitic carbon bodies in liquid nitrogen show extremely high wear, and friction is more than twice that obtained in room air. In nitrogen, neither moisture films nor surface oxides form on the mating metal.

Using Solid Lubricants: The most successful uses of solid lubricants have employed resinous bonding agents including materials used as insulating cements in electrical equipment. This method of application has definite limitations due to endurance life. In other problem areas, temperature limitations are also important. Once the solid lubricant film is worn away, or otherwise displaced from the bearing surface, it will not be regenerated, and useful life of the part may be ended. A 600 F limiting temperature in some electrical equipment is well within the temperature range for effective lubrication with several commercial solid-film lubricants. Effect of temperature on friction coefficient is shown in Fig. 1 for resin-bonded molybdenum disulfide. Here, temperature limit is a function of bonding resin. Molybdenum disulfide has a temperature limitation of 750 F where oxidation can be detected.

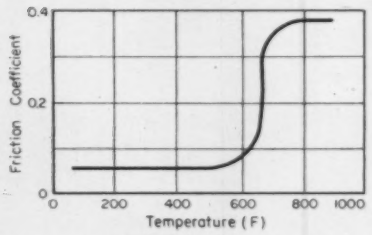

Fig. 1—Effect of temperature on friction of molybdenum disulfide. Temperature limit is a function of bonding resin. Oxidation begins at approximately 750 F.

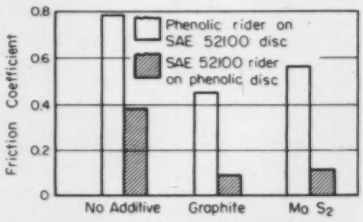

Fig. 2—Effect of lubricant additives on friction of laminated phenolics. Speed of riders on discs was 2300 fpm under 1000 gram load. Measurements were made in dry air at 75 F.

Liquid or gas carriers could be potent methods of utilizing solid lubricants. Stable suspensions of many solids, however, are difficult to prepare. Further, liquid carriers can displace solid lubricants from the surface because the liquid is capable of physical adsorption. In this case, the solid is no longer the lubricant, and the carrier may not provide necessary lubrication. Very high concentrations of solids (greater than 10 per cent) may be necessary to prevent displacement of solid particles from the load-bearing area.

An air or gas fluid-dispersion technique for carrying solid lubricants to rolling contact bearings has been used successfully. This technique requires very careful control to assure supply of the solid at the optimum rate to provide lubrication without destroying dimensional tolerances. Use of a liquid carrier that will volatilize at operating temperature of the bearings has distinct advantages. For example, metering the supply rate is much easier with a liquid carrier. Also, heat of vaporization of the carrier can be utilized in cooling lubricated parts. With a single-pass system, an agitated slurry of the solid in its carrier fluid can be used. Thus, lack of stability of solid suspensions need not be a problem.

Rolling-contact fatigue studies that included lubrication with powders and slurries of solid graphite and molybdenum disulfide show that fatigue life of the balls is substantially less when a solid lubricant is used rather than either petroleum or synthetic-base turbine oils. Solid particles serve to increase surface stresses, thus reducing fatigue life. Initial fatigue failures occur in regions of pure rolling and not in areas where there is significant surface slip. Slip helps to build uniform films of the solids, and individual particles do not serve as stress raisers in these areas.

Fabric-laminated phenolic resins are used successfully as rolling-contact-bearing cage materials with liquid or grease lubricants. A number of similar materials have been developed which contain solid lubricants and are effectively self-lubricating in many applications. Fig. 2 shows the beneficial influence of small amounts of solid lubricants in plastic phenolic laminates. Dissipation of frictional heat and high ambient temperatures may limit the usefulness of plastic materials in the absence of a liquid coolant. Teflon may be more useful at higher temperatures than phenolics but require reinforcement to provide acceptable mechanical strengths.

Molded carbon-graphite is self-lubricating and is widely used for bearings and seals. Brittleness prevents its general use in bearing cages. Special cage designs with a metal support may make the use of carbon sliding surfaces possible. As previously mentioned, a surface film of adsorbed vapor or surface oxides is needed to establish a lubricating film with graphite.

From a paper entitled "Possibilities in the Field of Dry Lubricants," presented at the SAE Annual Meeting in Detroit, Michigan, January, 1958.

Circle 497 on Page 19→

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Helpful Literature
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For copies of any literature listed, circle Item Number on Yellow Card — page 19

Indicating Controllers

Line of indicating controllers for automatic control of pressure or temperature; transmitters for pressure or temperature indication; and receiver gages in various designs, ranges, and degrees of accuracy are described and illustrated in Catalog 510. Tables of ranges are included. 16 pages. American Machine & Metals, Inc., United States Gage Div., Sellersville, Pa. E

Circle 601 on Page 19

Caster Wheels

Properties that make Durastan caster wheels nonsparking, noninflammable, and resistant to abrasion and moisture are described in illustrated bulletin. Tables cover 4 to 6-in. diameter wheels with 1½, 2, and 2½-in. face widths. 2 pages. Rapids-Standard Co., 342 Rapistan Bldg., Grand Rapids 2, Mich. H

Circle 602 on Page 19

High Pressure Pumps

Type CB high pressure screw pumps for various oil services are detailed in illustrated Bulletin 252. Discharge pressures range up to 1000 psi and viscosities from 35 to 75,000 ssu. Technical details are given. 8 pages. Warren Pumps, Inc., Warren, Mass. B

Circle 603 on Page 19

Technical Data Books

Revised 1958 catalog of Lefax pocket-size technical data books lists the $1.25 books on machine design, machinists data, metals, power transmission machinery, mechanics of materials, physical and thermodynamic data, hydraulics, transformers, meters and relays, general math. and other subjects. Each 140-page, loose-leaf book contains up-to-date data. Lefax Publishers, Philadelphia 7, Pa. E

Circle 604 on Page 19

Printed Circuit Connector

Specifications, outline dimensions and general data on the Continental Connector Series 672 printed circuit test block connector is found in data sheet. Six and sixteen-contact models are offered. 2 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 605 on Page 19

Fasteners

Listings of all standard sizes, plus many extra stock items, are found in Net Price Catalog 711. Prices are given for nonferrous and stainless steel bolts, nuts, screws, rivets, and washers. Bulk and package prices are given. 84 pages. H. M. Harper Co., 8299 Lehigh Ave., Morton Grove, Ill. J

Circle 606 on Page 19

Servomotor

Size 15 servomotor which offers acceleration at stall of 100,000 radians per second^2 is subject of Data Sheet 1258. The 8-oz unit for 115-v, 400-cycle operation can be used at 200° C. Specifications are given. 4 pages. Helipot Corp., Newport Beach, Calif. L

Circle 607 on Page 19

Cylinders

Both JIC and automotive industry automation standards are met by the S-2 line of air and hydraulic cylinders, described in illustrated Bulletin SS-58. Mounting data for 11 models are given. Bore sizes range from 1½ to 8 in. 4 pages. Hydro-Line Mfg. Co., 5600 Pike Rd., Rockford, Ill. K

Circle 608 on Page 19

Electrical Connectors

Major series of Pyle-Star-Line electrical connectors described in Bulletin 1252-1 are the Series W for environmental performance and the Series C (circuit breaking) for portable and detachable industrial equipment. Wide choice of pin and socket contact configurations has from 4 to 100 poles. 62 pages. Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill. F

Circle 609 on Page 19

Socket Screws

Microsize Unbrako socket head cap and set screws with Nylok self-locking feature are subject of illustrated bulletin. The high tensile strength fasteners are offered in heat treated alloy steel and 18-8 stainless steel grades. 4 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 610 on Page 19

Foam Plastic Products

Many of the custom low temperature insulation, buoyancy, and packaging products molded or fabricated of Dow Styrofoam and Koppers Dylite are shown in catalog. Many applications for these polystyrene foam plastic products are described. Glo-Brite Products, Inc., 6415 N. California Ave., Chicago 45, Ill. J

Circle 611 on Page 19

Thermal Conductivity Cells

Specifications are provided for hermetic and mechanical seal types of hot wire and thermistor cells in Bulletin TCTH. Gas Analysis T/C cells for chromatography and "on stream" instrumentation are described as to general data and typical deflection values. 6 pages. Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J. D

Circle 612 on Page 19

Glass-Bonded Mica

All types of Mykroy glass-bonded mica, Thermica synthetic powdered mica, and other high frequency insulating materials for use in electronic equipment are descriptively covered in Bulletin 101. Materials withstand up to 1200° F. 6 pages. Electronic Mechanics, Inc., Clifton, N. J. D

Circle 613 on Page 19

Cold-Formed Metal Shapes

Handbook MS 158 explains and illustrates basic principles of roller die, cold forming metal shapes. Material selection, roller dies, forming mills, tolerances for roll forming, and typical metal shapes are covered. 48 pages. Van Huffel Tube Corp., Warren, Ohio. G

Circle 614 on Page 19

Power Transmission Equipment

Selection charts for heavy-duty QD sheaves, lightweight and QD Junior sheaves, Worthington-Goodyear V-belts, and variable speed drives are found in general Catalog 7900-B1. It is compiled to aid design engineers in choosing mechanical power transmission equipment. 12 pages. Worthington Corp., Harrison, N. J. C

Circle 615 on Page 19

Optical Parts

Information contained in Catalog L-117 on full line of unmounted optical parts, including lenses, prisms, and reflectors, makes it easy for prospective users to describe their optical needs. Special section covers quartz and special optics. A new price list is included. 16 pages. Bausch & Lomb Optical Co., Rochester 2, N. Y. F

Circle 616 on Page 19

Pneumatic Power Actuator

Bulletin B-50-3 describes operation and versatility of the Series 50 cylinder Conomotor, a pneumatic power actuator used in process industries for throttling control. More than 20 applications are illustrated. 12 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. E

Circle 617 on Page 19

Fan & Blower Motors

Design, dimension, rating, performance, and application data on shaded pole motors for fan and blower applications are featured in Bulletin GEA-6134B. Covered are motors rated 1.5 w through ⅛ hp. Motor applications include appliances, unit heaters.

(Advertisement)

Chemical Prepaint Treatments for Metal Surfaces

What they do, the types available, how they are applied

By J. H. GEYER
Manager, Product Development Dept., AMERICAN CHEMICAL PAINT COMPANY

Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

The prepaint preparation of the metal surface is therefore a highly important part of the system. Chemical prepaint treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

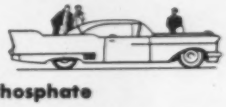
Basically, there are four types of chemical prepaint treatments. These are phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate. Each is discussed briefly in the following paragraphs.

Phosphoric Acid

Perhaps the most widely used and certainly one of the most economical chemical prepaint treatments is the phosphoric acid cleaner combination materials. ACP Deoxidine® is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate

Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances such as water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine,® ACP's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate

ACP Granodine® is an example of this type of chemical prepaint treatment process, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, and acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. ACP Lithoform® is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

Amorphous Phosphate and Chromate

These coatings are the films produced by the ACP Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, mechanical spraying, or roller coating equipment. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip, spray or roller coating application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

The major chemical prepaint treatments for metals have been covered briefly in this article. More complete information can be had by contacting an ACP sales representative or by writing us at Ambler, Pa.

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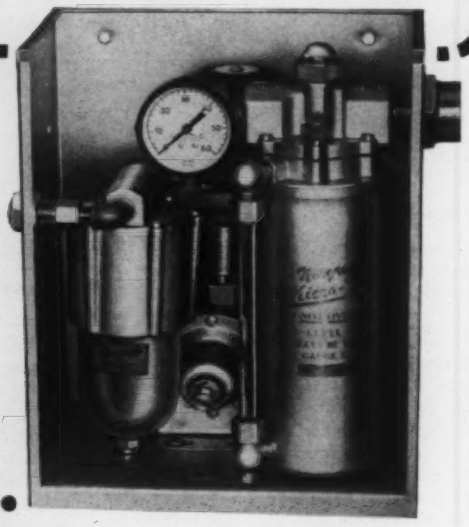

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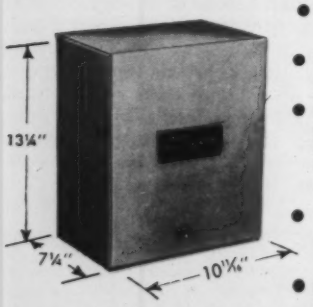

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furnace heaters, dehumidifiers, and evaporative coolers. 12 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 618 on Page 19

Flexible Air Duct

Type 8K-1D flexible air duct described in engineering data sheet will handle dry, free-flowing bulk materials and can be used for heavy-duty exhaust applications. It combines neoprene-coated cotton fabric with steel spiralling. 2 pages. Wiremold Co., Hartford, Conn. B

Circle 619 on Page 19

Photoelectric Controls

Normal, high speed, ultra sensitive, and impulse actuated photoelectric controls, plug-in mounted photoelectric controls, timing controls, light sources, electronic timers, and controls operated by current surge and impact are described in Catalog 58. Illustrations and application diagrams supplement text. 24 pages. Autotron, Inc., Box 722X, Danville, Ill. J

Circle 620 on Page 19

Self-Locking Screws

Standard sizes, Rockwell C hardness, and tips on application are given in bulletin for socket head cap, button head socket, flat head socket cap, socket set, and shoulder screws, and dryseal pressure plugs. Screws feature Nylok self-locking nylon pellet in the threads. 4 pages. Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio. G

Circle 621 on Page 19

Belt Drives

Timing belt drive Catalog TB-58, in addition to engineering information, contains data on 1/5, ⅜, ½, ⅞, and 1¼ in. pitches. Selection and installation details are included. Drives are used for power transmission up to 600 hp, synchronizing two or more shafts, to convey, or control motion. 66 pages. Write Morse Chain Co., Ithaca, N. Y. D

Circle 622 on Page 19

Resin Plastics

Physical property and application data on all Naugatuck plastics are condensed in 1957-58 resin guide. Included are details on seven types of Kralastic resin-rubber, seven types of Vibrin polyester resin, and 12 types of Marvinol vinyl resin. 8 pages. United States Rubber Co., Naugatuck, Conn. B

Circle 623 on Page 19

Ventilating Fan Units

Bulletin UVS-104 covers belt-driven ventilating units with either forward curve wheels or backward blade non-overloading wheels. Twelve basic sizes are covered as to performance, engineering data, selection and installation. 24 pages. General Blower Co., Morton Grove, Ill. I

Circle 624 on Page 19

Welding Fittings

Proper ways to prepare orders for welding fittings and flanges are explained in Bulletin FB-503. A list of the seamless welding fittings, tubular products, and extrusions available

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are included. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Milwaukee 48, Wis. C

Circle 625 on Page 19

Hollow Rivets

A comprehensive selection table and use data are combined in this folder on POP rivets, including the new cadmium-plated steel type. Cross-sectional diagrams show working principle. Power and hand tools for setting rivets are described. 4 pages. United Shoe Machinery Corp., POP Rivet Div., West Medway, Mass. B

Circle 626 on Page 19

Chemical Metal Treatment

Brochure 1413A is "ACP Guide to the Chemical Treatment of Metals." It describes chemical conversion coatings for steel, aluminum, galvanized, iron, zinc, and cadmium plated surfaces; for corrosion resistance, paint bonding, and forming; and for protection of friction surfaces. 8 pages. American Chemical Paint Co., Ambler 1, Pa. E

Circle 627 on Page 19

Digital Computer

Simplified programming of the Bendix G-15 general purpose digital computer is featured in descriptive Bulletin AB-116. Engineers can be taught coding techniques within 2 to 4 hours. Specifications are covered. 6 pages. Bendix Aviation Corp., Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif. L

Circle 628 on Page 19

Gamma Radiation Generator

Technical Report AM-100 on the "Production of Gamma Radiation with a Linear Electron Accelerator" covers radiation lengths, forward intensity, angular distribution, total conversion efficiency, spectral shape, and shielding calculations. Applied Radiation Corp., Walnut Creek, Calif. M

Circle 629 on Page 19

Air & Hydraulic Valves

Cross-sectional illustrations are used in Catalog 58-59 to show operating principle of Shear-Seal valves for oil, water, and air control at pressures up to 6000 psi. Characteristics and data are presented to aid in selection and application. Engineering section covers control data. 56 pages. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 630 on Page 19

Specialized Papers

Data File on specialized papers deals with types that resist flame, fungi, rot, moisture, and other biological and chemical conditions. Information is given to speed use of papers in packaging, electrical, construction, fabrication, insulation, and other industries. Mosinee Paper Mills Co., Mosinee, Wis. K

Circle 631 on Page 19

Time Delay Relays

Tech Data No. 1357 describes a line of electronic time delay relays. These subminiature, transistorized relays have time delays from 0.01 to

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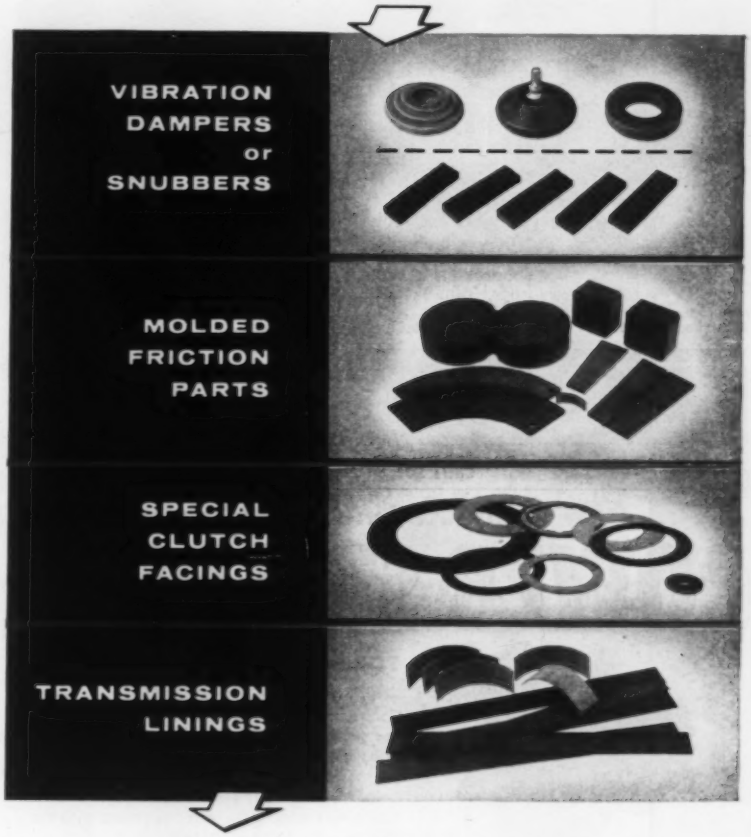

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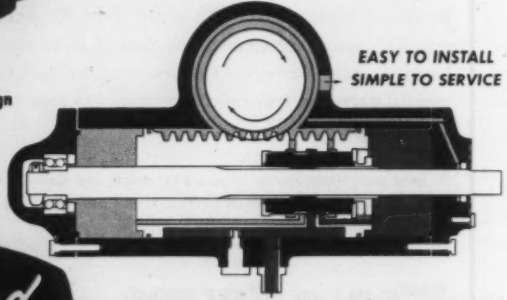

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Circle 502 on Page 19

60 seconds or longer. They will withstand temperature extremes as well as shock and vibration. 4 pages. Tempo Instrument Inc., 240 Old Country Rd., Hicksville, N. Y. D

Circle 632 on Page 19

Thermometers

Details of a complete line of rectangular case, filled system, indicating, recording, and controlling thermometers are given in Catalog C60-2. Information is also presented on electric and pneumatic control instruments, and on accessories. 56 pages. Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Avenues, Philadelphia 44, Pa. E

Circle 633 on Page 19

Machine Tool Relays

"Relays by Westinghouse for Industrial Automatic and General Auxiliary Control" is title of Bulletin B-7073. Various types are described briefly, and their control ranges and characteristics are given. 12 pages. Westinghouse Electric Corp., Pittsburgh 30, Pa. F

Circle 634 on Page 19

Motor Frame Sizes

Compar-A-Frame Bulletin B-1284-1 tabulates comparative dimensions of protected and fan-cooled alternating current motors in the new NEMA frame sizes from 364U to 445U. Frame assignments are given. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 635 on Page 19

Integrating System

Performance and application information on the Model 270 integrating system for time integral measurements of dynamic phenomena in research and quality control are given in bulletin. 4 pages. Allegany Instrument Co., 1091 Wills Mountain, Cumberland, Md. C

Circle 636 on Page 19

Flexibilizer

Expanded data sheets deal with the properties and applications of Cardolite epoxy resin flexibilizer NC513. It is usable in electrical, tooling, adhesive, and laminating industries. Minnesota Mining & Mfg. Co., Irvington Chemical Div., 500 Doremus Ave., Newark 5, N. J. J

Circle 637 on Page 19

Digital Control

Five new components for use as digital actuators and feedback devices in servo and instrumentation systems are described in bulletin entitled, "Digitometry, A Concept of Digital Control and Indication." 4 pages. Anatran Corp., 45 W. Union St., Pasadena, Calif. L

Circle 638 on Page 19

O-Rings

Technical Data Reference Log No. 1581 offers guidance in the selection and use of O-rings. Simplified product designs and installation methods are pointed out. Engineering guide gives details on inter-relationship between Military and industrial standards. 16 pages. Plastic & Rubber

Products Co., 2100 Hyde Park Blvd., Los Angeles 47, Calif. L

Circle 639 on Page 19

Wheeled Conveyor Rails

Three specification sheets give dimensions and engineering data on line of Wheelrail conveyors for use in live storage racks, table racks, and gravity wheel conveyors. Sage Equipment Co., 30 Essex St., Buffalo 13, N. Y. F

Circle 640 on Page 19

Fire-Safe Files

The features and locking arrangements which adapt Safe-Files for safeguarding business records from possible theft, prying eyes, and fire are cited in Booklet SC-798. Sperry Rand Corp., Remington Rand Div., 315 Fourth Ave., New York 10, N. Y. D

Circle 641 on Page 19

Acceleration Testers

Precision testing of simulated operational G-loadings under MIL-E-5272A specification is subject of Technical Bulletin S-1. It also describes the Rucker Centrifuge acceleration test machines. 6 pages. Rucker Co., 4700 San Pablo Ave., Oakland, Calif. M

Circle 642 on Page 19

Variable Speed Drives

Operation and performance data on the Fincor variable speed drive are presented in Bulletin 1257-1. Offered in 1/6 to ½-hp packaged units, drives operate on 3-phase 220-v 60-cycle ac. 4 pages. Fidelity Instrument Corp., 1000 East Boundary Ave., York, Pa. E

Circle 643 on Page 19

Industrial X-Ray

Question and answer booklet deals with x-ray diffraction, diffractometry, and spectrography. 16 pages. Philips Electronics, Inc., Instruments Div., 750 S. Fulton Ave., Mount Vernon, N. Y. D

Circle 644 on Page 19

Electrolytic Capacitors

Tentative specifications, characteristics, and test conditions for the tan-TI-cap line of solid tantalum electrolytic capacitors are given in Bulletin DL-C 859. These small size units are rated for 6 to 35 v, 4 to 200 mfd, and −80 to 85° C. 4 pages. Texas Instruments, Inc., Box 312, Dallas, Texas. I

Circle 645 on Page 19

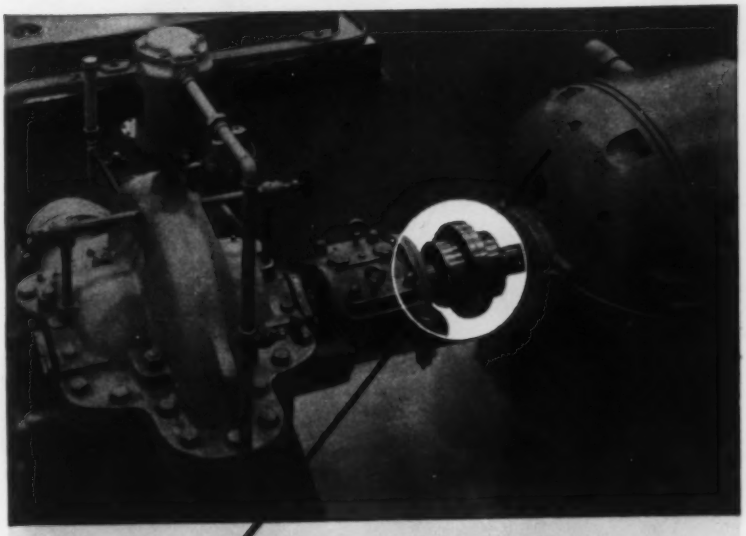
Potentiometers

General specifications on line of ⅞-in. precision potentiometers are given in Technical Data Sheet No. 103. They are offered in resistance values from 100 to 25,000 ohms, with 273 to 1120 nominal resolution in turns. 2 pages. Carter Mfg. Co., 23 Washington St., Hudson, Mass. B

Circle 646 on Page 19

Coupling Assemblies

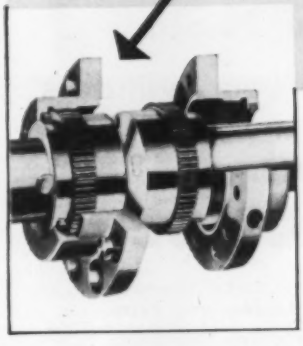
Usable on hoses, piping, and fixtures, OPW-Jordan Kamlok Quick Couplers are offered in ½ to 6-in. sizes. Catalog F-10-R describes available types and constructions for han-



Waldron coupling on centrifugal pump installation

WALDRON

flexible couplings...



USED IN HUNDREDS OF DIFFERENT APPLICATIONS BUT ALWAYS FOR THE

same 3 reasons

1 **STRENGTH**—Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

2 **RELIABILITY**—There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is at the lowest possible diameter where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

3 **SERVICE**—Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

Ask for Catalog 57

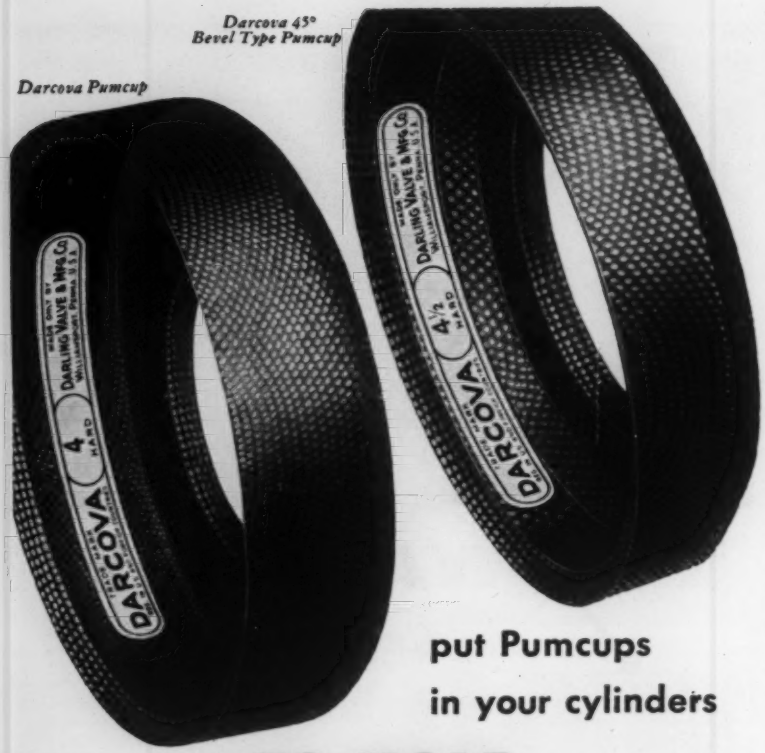
JOHN WALDRON CORP.

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities

Export Agents—Frazar & Co., New York, N. Y.

Circle 503 on Page 19



put Pumcups
in your cylinders

TO HOLD PRESSURE LONGER!

In Darcova Pumcups a sound engineering principle has been combined with precision tolerances and extremely durable compositions to provide exceptional efficiency and life in hydraulic, air, and reciprocating pump cylinders of all kinds.

Unlike ordinary piston packing, precision Pumcups are engineered to minimize friction load while hugging cylinder walls on every pressure stroke. Regardless of eventual wear, efficiency *stays* high! So there's far less down-time and need for replacement.

Pumcups are made in a wide range of sizes, types and texture-engineered compositions, including 100% Nylon, for all kinds of pressure-temperature-fluid conditions. Send for Pumcup Bulletin 5503 and weigh all the facts!

DARLING VALVE & MANUFACTURING CO.
Williamsport 30, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
TRADE MARK
PUMCUPS

dling range of temperatures, pressures, and fluids. 8 pages. OPW Corp., Jordan Industrial Sales Div., 6013 Wiehe Rd., Cincinnati 3, Ohio. G

Circle 647 on Page 19

Gears

Complete information on the Bond stock gear line is presented in Catalog No. 100. Color indexing aids in obtaining information on speed reducers, gears, sprockets and chain, flexible couplings, universal joints, collars, and pillow blocks. Engineering section contains formulas and tables relating to gearing and mechanical power transmission. 80 pages. Charles Bond Co., Gear Div., 617-23 Arch St., Philadelphia 6, Pa. E

Circle 648 on Page 19

Printed Circuits

Materials, specifications, design tolerances, and application information on printed circuits are contained in file folder type brochure. How Protomaka equipment is used to make printed circuits is explained, and the Narcus process for plating holes is described. 6 pages. Printed Electronics Corp., 7 North St., Natick, Mass. B

Circle 649 on Page 19

V-Belts

Series of four illustrated booklets describes Goodyear Green Seal V-belts, the raw materials that go into them, the machines and processes of production, and the testing, inspection, and control of their quality. 16, 16, 16, and 20 pages, respectively. Goodyear Tire & Rubber Co., Akron 16, Ohio. F

Circle 650 on Page 19

Circuit Analyzer

Line of automatic circuit analyzers is described in detail in illustrated, plastic-bound brochure. Specifications are also given for high voltage analyzers, multiplier sections, functional tester, military models of this equipment, and accessories. 22 pages. Dit-Mco, Inc., 911 Broadway, Kansas City 5, Mo. I

Circle 651 on Page 19

Phosphating Coatings

CrysCoat No. 89, an iron phosphating compound that cleans and phosphates metal at the same time, and CrysCoat HC, a zinc phosphating compound that gives a heavy coating in tank application, are subjects of two illustrated folders. Step-by-step instructions are given. 4 pages each. Oakite Products, Inc., 19 Rector St., New York 6, N. Y. D

Circle 652 on Page 19

Lock Nuts & Fasteners

Product descriptions, illustrations, dimensions, screw tensions, materials, finishes, and typical applications for line of Palnut lock nuts and fasteners are presented in catalog. Locking principle is covered. 28 pages. Palnut Co., 61 Glen Rd., Mountainside, N. J. D

Circle 653 on Page 19

Three-Dimensional Cams

The three-dimensional cam—heart of an automatic analog computer—

Circle 504 on Page 19

is described and illustrated in Bulletin 455S. How it is engineered and what and where it can be used are detailed. Examples are shown. 4 pages. Parker-Hartford Corp., Cam Div., 650 Franklin Ave., Hartford, Conn. B

Circle 654 on Page 19

Ammonia Valves

Ammonia valves and accessories for refrigeration and industrial applications are described in Catalog 202. Henry Valve Co., 3215 North Ave., Melrose Park, Ill. J

Circle 655 on Page 19

Tungsten Carbides

"This is Metal Carbides" is title of illustrated folder which describes facilities for producing hot and cold pressed tungsten carbide products. Pictorial "tour" takes the reader through the entire production process from raw material to finishing. 24 pages. Metal Carbides Corp., Youngstown, Ohio. G

Circle 656 on Page 19

Bushings

Acme or ASA standard bushings can be chosen with this plastic slide rule type selector which gives data on over 30,000 drill bushings. The OD and ID of lines are given in decimals. Acme Industrial Co., 200 N. Laflin St., Chicago 7, Ill. I

Circle 657 on Page 19

Electrochemical Products

Physical facilities and experience in production of electronic and electromechanical products and assemblies are outlined in illustrated brochure. Engineering, research, design, and production facilities are presented. 12 pages. Gray Mfg. Co., Industrial Div., 16 Arbor St., Hartford, Conn. B

Circle 658 on Page 19

Fluid Power Drives

Advantages, operation, and characteristics of Any-Speed fluid power drives are explained in illustrated Bulletin 10600. Performance curves and block diagrams for various applications are given. 32 pages. Oilgear Co., 1570 Q W. Pierce St., Milwaukee 4, Wis. K

Circle 659 on Page 19

Electrical Control Equipment

Applications, construction details, engineering information, and operating features are discussed in Catalog 18 on automatic electrical control equipment. Four sections cover transfer switches, contactors, special controls, and timing devices. 64 pages. Zenith Electric Co., Dept. MDC, 152 W. Walton St., Chicago 10, Ill. J

Casters & Wheels

Revised standard bulletin details sizes and dimensions for industrial casters and wheels and indicates general duty classifications by sizes. Casters are used on platform trucks, towline carts and other materials handling equipment. 8 pages. Bulletin is available only on letterhead request to Caster & Floor Truck Manufacturers' Association, 27 E. Monroe, Chicago 3 Ill. J

Advanced aluminum rotor casting process prevents air bubbles and shrinkage that cause stress and trouble!

For over a third of a century Baldor has pioneered many new ways to build electric motors better . . . for less money. Baldor's aluminum-cast rotor in the new NEMA frames is a good example.

This careful, precision method of casting produces a rugged, stress-free rotor without air bubbles and shrinkage cavities that can cause broken bars . . . loss of power . . . and motor damage! New design refinements have also improved torque characteristics while lowering the noise level.

Engineering extras like this (without extra cost) are your guarantee that you can specify Baldor Streamcooled Motors with complete confidence.

FOR MORE INFORMATION ON THE COMPLETE LINE OF BALDOR MOTORS, WRITE . . .

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Over 500 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn. Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Kansas City, Mo. Oakland • Philadelphia • Portland, Ore. • Syracuse.

Circle 505 on Page 19

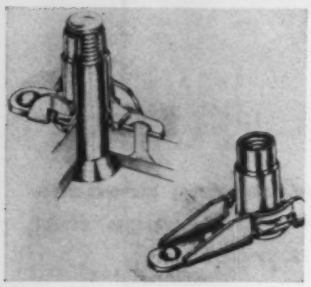
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Floating Anchor Nuts

self-locking units have deep counterbore

Counterbored, self-locking, floating anchor nuts speed production and reduce weight of airframe and aircraft components where members of varying thicknesses must be joined. Deep counterbore design permits elimination of multiple shims, thus reducing weight of nuts. Configurations include a two-lug anchor nut, a one-lug unit, and gang channel assembly. Designed for service at temperatures



to 550 F, nuts meet tensile, twist-out, and push-out requirements of AN-N-10 and/or MIL-N-25027 (ASG). One and two-lug units are available in thread sizes No. 10-32, ¼-28, and 5/16-24. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J. D

Circle 660 on Page 19

Silicon Rectifier

controls volume of output power

New silicon controlled rectifier simultaneously changes alternating current to direct current and controls volume of power fed into a load. Developmental models handle loads from 200 to 1000 w at stud temperature of 125 C. When switching at full rating, rectifier dissipates only 0.005 per cent of controlled power. Six sample models

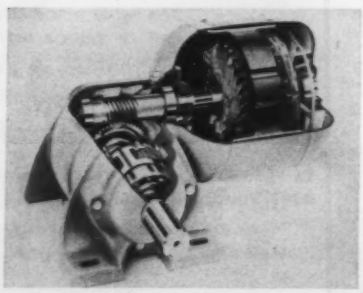
are rated at average forward current of 5 amp at 125 C stud temperature, and at 25, 40, 75, 100, 150, and 200 peak inverse voltage. All models have typical gate current to fire of 10 ma at 25 C, and typical minimum holding current of 10 ma. **Semiconductor Products Dept., General Electric Co.,** Electronics Park, Syracuse, N. Y. C

Circle 661 on Page 19

Gearmotors

are single planetary units in ¼ to 1-hp models

New combination single planetary, integrally mounted gearmotors provide low speeds of double-reduction units with advantages of compact design and light weight. Frame is heat-treated aluminum alloy. A ½-hp unit at 14.5 rpm delivers 1260 lb-in. torque output, but is only 14 5/8 in. long and 13 15/16 in. wide. Motor and worm shaft are joined by a tang coupling to facilitate assembly and disassembly without disturbance to



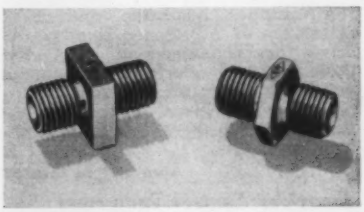
gears or driven mechanism. Planet cage and output shaft are a single piece, and planets turn on needle bearings. Units are available in foot or ring-mounted frames, ¼ through 1 hp, 38 through 3 rpm. **Electra Motors Inc.,** 1110 Lemon St., Anaheim, Calif. L

Circle 662 on Page 19

Thermal Relief Valve

miniature unit is for −65 to 400 F temperatures

Mini-Relief is a miniature thermal relief valve which is made in tube size 4 (¼ in.). Set pressure range is 1000 to 4100 psi, factory-set to any pressure within range. Unit meets or exceeds requirements of specification MIL-V-5527, except that it is not adjustable. It is suitable for applications where cracking pressure adjustments are not required. Rated flow at set pressure is 0.25 gpm. Valve accommodates any medium compatible with



18-8 and 440F stainless steels, and is for temperatures from −65 to 400 F. **Republic Mfg. Co.,** 15655 Brookpark Rd., Cleveland 11, Ohio. G

Circle 663 on Page 19

Aluminum Adhesive

can be used also as paint, sealer, insulator, and primer

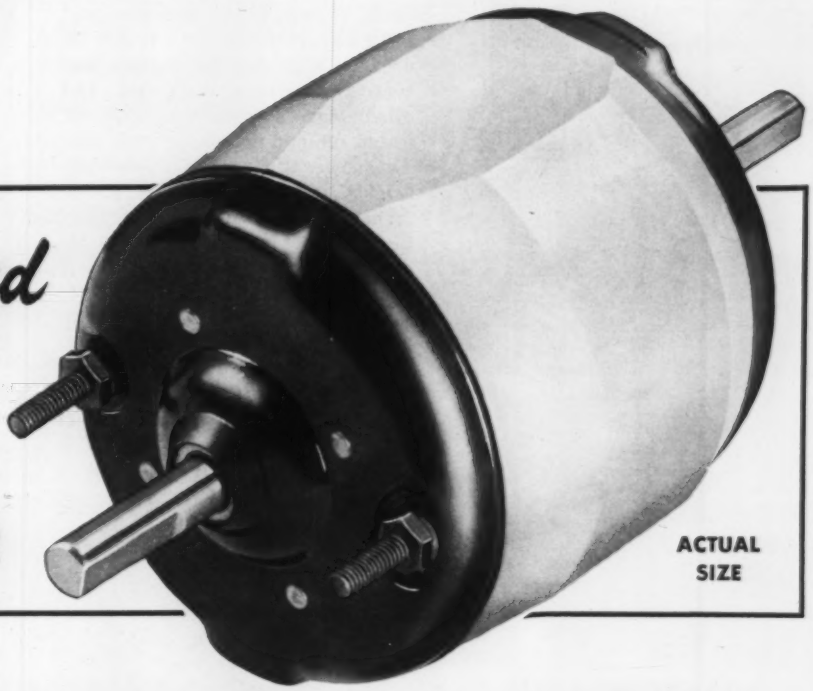
Aluminum pigment is combined with resins and rubber to formulate an all-purpose adhesive which can also be used as paint, as a sealer, insulator, and primer. Des-

MORE HORSEPOWER...

in an Economical, Compact, Quality Package

Redmond

Series
Type
MICROMOTOR



ACTUAL SIZE

Especially Designed for Actuators and All Applications Where High Starting Torque Is Needed

The Redmond type TW series MicroMotor is an especially designed actuator motor—not a modified heater motor of conventional stamped steel construction. The stator core is precision die cast to make a rigid, durable motor. The exact bearing alignment and uniformity of air gap result in a motor that will give you years of trouble-free service and quiet operation.

The TW series motor is available with 6 volt DC to 115 volt AC or DC performance winding. The horsepower range is 1/150 to ¾, depending on the speed and type of duty required.

This motor is ideal for pumps, can openers, chair vibrators and actuators, blowers, hedge trimmers, and tape dispensers. Typical automotive applications are window and seat actuators, top lifts, evaporative coolers, and air-ride compressors.

Write, wire, or telephone either the Redmond office nearest you or the home office, and our sales engineer will show you how this motor can save money on your application.

Your Nearest Redmond Engineering Field Office Has Complete Information for You

Eastern Office
850 Broad Street
Newark 5, New Jersey
Phone: Mitchell 2-3990

Southeast Office
1720 Section Road
Cincinnati 37, Ohio
Phone: Melrose 1-3153

Mid-West Office
Fair Oaks Bldg.
6525 W. North Ave.
Oak Park, Illinois
Phone: Village 8-5721

Southwest Office
210 Suburban Building
5526 Dyer Street, Dallas,
Texas Phone: Emerson 8-4461

Western Office
1260 S. Boyle Ave.
Los Angeles 23, California
Phone: Angelus 3-6710

MAIN OFFICE
201 Monroe Street
Owosso, Michigan
Phone: Saratoga 5-5151

The Standard of Dependability

Redmond
COMPANY, INC.
OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

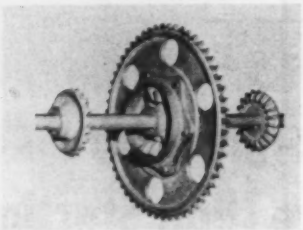
THE BIG NAME IN SMALL MOTORS

ignated Alum-O-Bond, the product can be used as a waterproof aluminum paint for exterior surfaces, models, house members, and for general utility use. It can be used as a primer for marine use, coating for fishing equipment, and other places where resistance to water, oil, and grease are essential. As a sealer it can be used for windshields, gaskets, and pipe joints. It has excellent dielectric properties, making it effective as an insulator. Used as an adhesive, it bonds all surfaces, is especially effective with metal and aluminum. It is available in half-pints, pints, quarts, gallons, drums, and in a 3-oz brush-top bottle. **W. J. Ruscoe Co.**, 483 Kenmore Blvd., Akron 1, Ohio. G

Circle 664 on Page 19

Differential Assembly

for drives to 6 hp



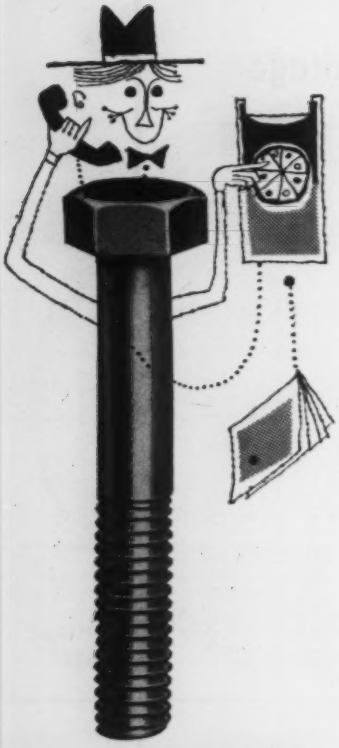
Small-sized, compact differential assembly for drives to 6 hp gives equal power to both wheels and permits easy and shortened turning. It is designed for horizontal or vertical-shaft engines on self-propelled and riding lawn mowers, garden tractors, golf buggies and other small vehicles. Unit can be used with either forward or reverse action. Measuring 5⅛ x 3⅜ in., it has a six-bolt flange on which a sprocket of any size can be mounted. Axle bore is from ½ to 1 in. in diam. Differential uses 3/16-in. keyways on axle bores from ½ to ¾ in. **Cizek Mfg. & Distributing Co.**, Clutier, Iowa. I

Circle 665 on Page 19

Glow Lamp

incorporates molded-tip construction

NE-2E is a small, versatile glow lamp (right) available for use as an indicator light. Molded-tip con-



ALCOA ALUMINUM FASTENERS ARE AVAILABLE LOCALLY!

Yes, you have only to pick up your phone to "call in" the Alcoa® Aluminum Fasteners you need. Your local Alcoa distributor has them in all standard sizes and types for immediate delivery. "Specials" are available, too!

Get the lasting sales appeal that Alcoa Aluminum Fasteners give your aluminum products with their perfect color match, resistance to both galvanic and atmospheric corrosion. See the Yellow Pages of your telephone directory for your nearest Alcoa distributor.

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Gentlemen: Please send complete specification data and samples of Alcoa Aluminum Fasteners.

Name_____
Title_____
Company_____
Address_____

Circle 507 on Page 19

For LINEAR AND ROTARY POSITIONING

Specify **LimiTorque ACTUATORS**

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units for positioning machine parts or other assemblies requiring Linear or Rotary Motion.

LimiTorque is an electro-mechanical mechanism, using motor power through highly efficient and precision gearing, to impart Linear or Rotary motion . . . Limit switches are available to limit the travel in either direction—Thrust and Torque responsive switches control thrust or provide emergency shut-off. With LimiTorque it is possible to control full travel accuracy to within .2%—LimiTorque is easily and accurately controlled by the mere "push of a button".

LIMITORQUE IS BACKED BY 30 YEARS' EXPERIENCE IN MOTORIZING ALL TYPES OF VALVES—WHY NOT CONSULT US REGARDING ANY PROBLEM YOU MAY HAVE INVOLVING LINEAR ACTUATION; OUR ENGINEERS CAN NO DOUBT HELP YOU SOLVE THAT PROBLEM.

LimiTorque
PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

Circle 508 on Page 19

here's how Crucible Fatigue-Resistant Springs are made stronger to last longer

Crucible *fatigue-resistant* springs outlast conventional heavy-duty coil springs many times. That's because they are shot peened.

Shot peening actually makes the springs stronger by imposing a compressive stress on the surface of the spring that offsets some of the working stresses set up in service. Further, shot peening conditions the surface. The high intensity peening eliminates stress concentration points that could lead to failure of a conventional spring.

Moreover, when you buy Crucible springs, you employ all of Crucible's many years of experience and metallurgical know-how in fine steelmaking – from ore to finished spring. Good springs demand the best in specialty steels. During manufacture, quality checks are made continuously. And a final magnetic test may be given if desired.

When you have a requirement for a spring that must endure rugged operating conditions, secure the built-in advantages of Crucible *fatigue-resistant* springs. And for technical assistance in designing or selecting heavy-duty springs, don't hesitate to consult with Crucible's spring specialists. For a free copy of a handbook on "Coil Spring Design," write to *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE HEAVY-DUTY COIL SPRINGS

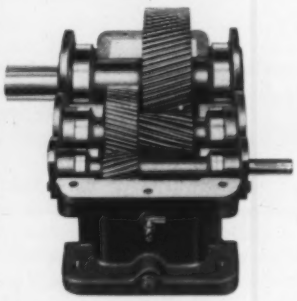
Circle 509 on Page 19

Wide range of large
H&S Speed Reducers
meets needs of
Webster Car Pullers

Here's a job that calls for rugged power and dependable gearing — pulling fourteen 75-ton railroad cars along a straight track, up a 1% grade, at a speed of 40 ft. per minute.

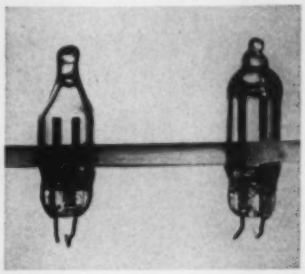
Webster Manufacturing, Inc., Tiffin, Ohio, easily solved this problem with the construction of a 50 HP Webster Car Mover. As part of this unit, Webster selected a Horsburgh & Scott Helical Gear Speed Reducer because it provided the necessary stamina for this high-torque job . . . unusually heavy bearings to withstand the greater overhung loads incident to car-puller operation.

From the same source — Horsburgh & Scott — Webster obtains the necessary extra heavy machine cut spur gears that drive the cable drum.



Seventy years of experience prove that *rugged construction* and *ample overload capacity* of H & S products assure trouble-free service and operating economy. Send us your requirements or contact your nearby H & S representative for prompt recommendations.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio



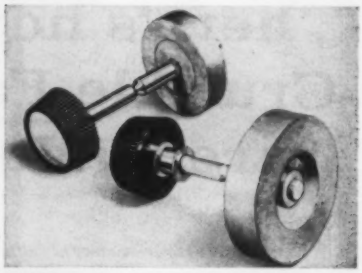
struction permits the use of longer electrodes for better end-on and side viewing, and uniformly centered tip provides improved appearance, both lighted and unlighted. Maximum overall length is ¾ in. Lamp operates on 110 to 125 v, in series with a 62,000-ohm resistor, and consumes 1/10 w. **Miniature Lamp Dept., General Electric Co.**, Nela Park, Cleveland 12, Ohio. F

Circle 666 on Page 19

Fly Wheel

for hi-fi and radio fine tuners

Lead-alloy fly wheel provides a heavy feel for precise, accurate knob control of high-fidelity and radio fine tuners. Available in weights of 4 and 8 oz, wheel is die-cast to slip over knurled shafts of



tuner knobs and hold with a press fit. No other fastening is required. **Staver Co.**, 41-51 N. Saxon Ave., Bay Shore, L. I., N. Y. D

Circle 667 on Page 19

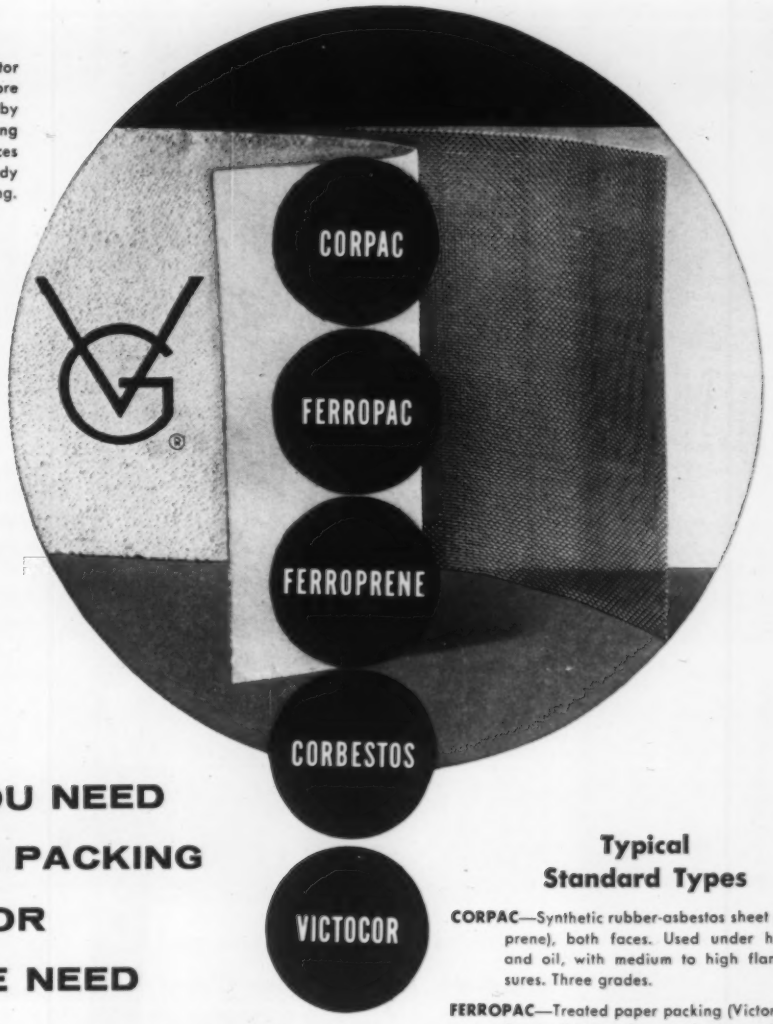
Nylon Tubular Bar

in OD range from ⅜ to 2 in.

Nylatron GS nylon tubular bar is now available in ODs from ⅜ to 2 in. It is used for close-tolerance fabrication of rollers, bearings, seals, washers, spacers, pipe unions, valve seats, gears, insula-

Circle 510 on Page 19

LOCKED-FOR-LIFE Victor construction. Packing and core are permanently bonded by means of formed tang projections on both faces of core, clinched into body of packing.



WHERE YOU NEED STEEL CORE PACKING VICTOR FILLS THE NEED

Where you're sealing under heavy loading, pounding or temperature, steel core packing is the modern specification. Its greater benefits and values are firmly established.

Actually it's the core that maintains a tight seal under tough conditions. It holds the packing in place, prevents shifting and extrusion. It resists torque loss on flattening because its effect on packing compressibility is nil.

From the widest range of highly engineered, SAE-ASTM rated packings, Victor literally can "tailor-make" steel core gaskets to your most precise specifications. Where needed, Victor successfully modifies the characteristics of standard types with virtually unlimited combinations and structures.

Get unbiased recommendations with complete technical and application data from your local Victor Field Engineer. Or contact the factory directly. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

Typical Standard Types

CORPAC—Synthetic rubber-asbestos sheet (Asbestoprene), both faces. Used under high heat and oil, with medium to high flange pressures. Three grades.

FERROPAC—Treated paper packing (Victorite), both faces. For service against gasoline, oil, grease, water, under medium flange pressures. Holds up under frequent dismantling.

FERROPRENE—Compressed asbestos sheet packing (Victopac) one side, compounded synthetic rubber (Victoprene) on other. Useful under high heat and oil; low to medium flange pressures.

CORBESTOS—General-purpose, beater-treated asbestos sheet packing for use on oil, gasoline, water, steam, antifreeze. Adaptable to all temperature and bolting pressure needs. Six standard structures including double-sided, single-sided, steel-faced and laminated.

VICTOCOR—Compressed asbestos sheet packing, both faces. Low torque loss. High heat and crush resistance. For high flange pressures on hot oils, gasoline, water, antifreeze.

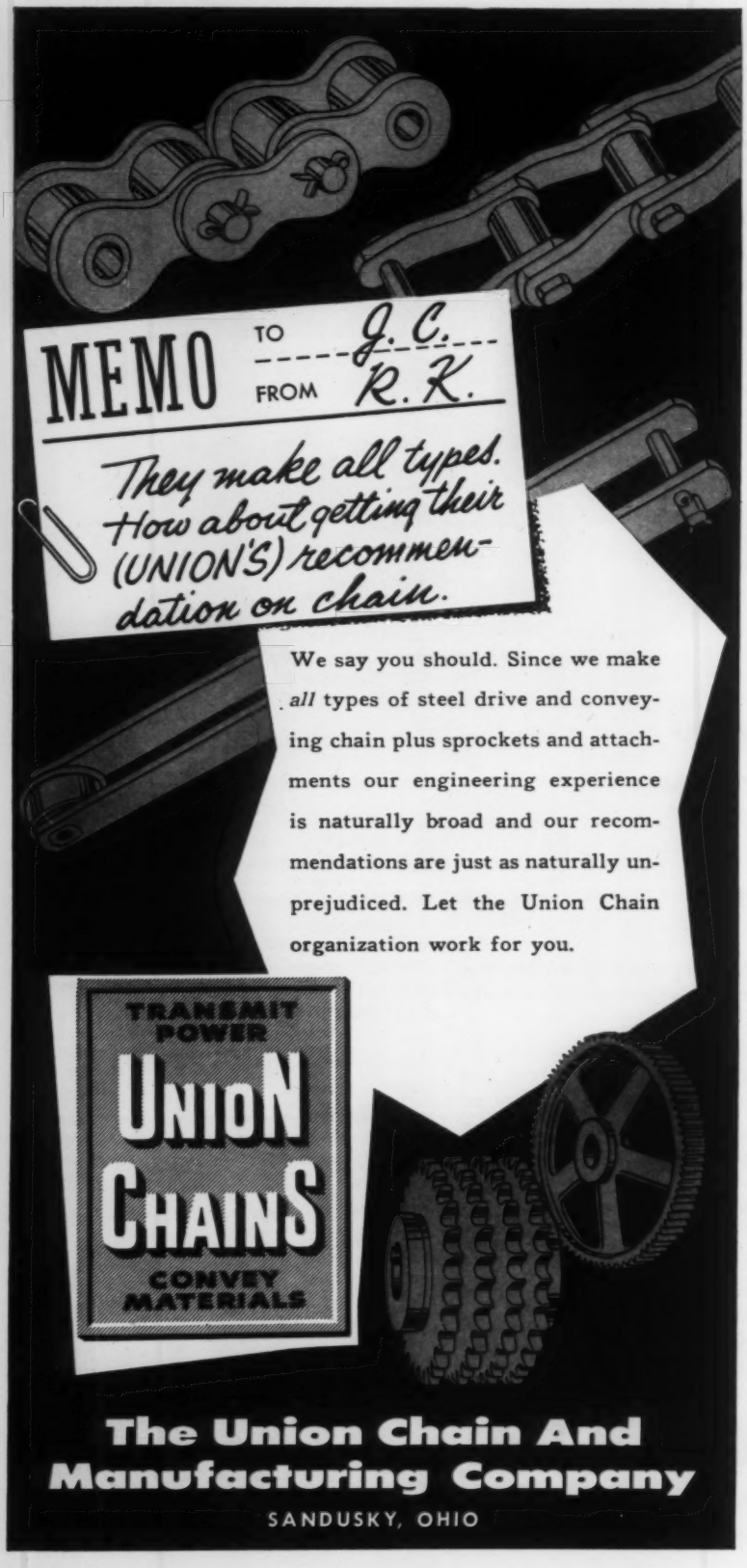
Your best sealing guide—Victor Gasket Engineering Catalog No. 505.

VICTOR

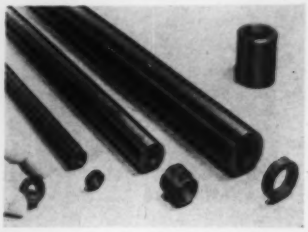
Sealing Products Exclusively

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 511 on Page 19


MEMO
TO J. C.
FROM R. K.
They make all types. How about getting their (UNION'S) recommendation on chain.
We say you should. Since we make all types of steel drive and conveying chain plus sprockets and attachments our engineering experience is naturally broad and our recommendations are just as naturally unprejudiced. Let the Union Chain organization work for you.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

tors, and other wear parts. Material, as compared to nylon 101, has higher modulus of elasticity, higher heat-distortion temperature, lower thermal expansion, lower coef-



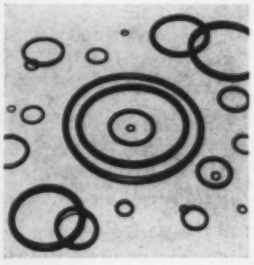
ficient of friction, and higher wear resistance in many applications. Standard availabilities include 19 sizes, from $\frac{3}{8}$ in. OD, with ID of $\frac{1}{2}$ in., through 2 in. OD with ID of $1\frac{1}{2}$ in. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa. C

Circle 668 on Page 19

O-Rings

for high-temperature uses

O-rings suitable for high-temperature applications are precision molded from SR 251-70 copolymer formulation. For general dynamic or static sealing applications with synthetic engine oils and hot fuels, recommended high-temperature limit is 450 F, and normal low-



temperature limit is – 40 F. Rings are available in all standard sizes from $\frac{1}{4}$ to 16 in. OD. **Stillman Rubber Co.,** 5811 Marilyn Ave., Culver City, Calif. L

Circle 669 on Page 19

Quick-Disconnect Coupling

for use with either liquid oxygen or nitrogen

New coupling for aircraft and missile use permits rapid disconnecting of liquid oxygen supply or

Engineered by Tinnerman...

It's a fastener...It's a friction-lock... It's a Tinnerman **SPEED NUT**® doing double-duty

Turn this Westinghouse Mobilaire® Fan to any angle... and it *stays* angled. The Tinnerman SPEED NUT Brand Fastener that holds the fan trunnions tight to the housing also supplies live spring-tension to keep the fan positioned at any angle you choose.

These SPEED NUT fasteners, developed by joint efforts of Tinnerman and Westinghouse designers, eliminate special adjusting thumb-screws. Only 2 SPEED NUT parts serve the purpose of several stampings and ordinary fasteners. Material and assembly costs are lower than with ordinary fastening methods. And the consumer gets a better fan that's easier to adjust.

Chances are that Tinnerman designers can develop SPEED NUT parts for your product to cut costs, speed production, improve that product.

Call your local SPEED NUT representative now ... if he's not in your Yellow Pages Directory under "Fasteners", write to:

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Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

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Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Machine tool designers solve hydraulic tubing problems with flexible *NYLAFLOW*

• Parts and components selected by machine tool builders must meet the strictest specifications and performance requirements. POLYPENCO® Nylaflow Pressure Tubing was chosen for the hydraulic wheel dressers and compensator units of the grinder shown above for these important reasons:

high strength (pressurized at 500 psi) with relatively small size and light weight

retains form—does not sag and foul machine controls

ease of handling

savings in installation

use of standard fittings

• *NYLAFLOW* Pressure Tubing is a tough, flexible polyamide tubing with this unique combination of performance characteristics:

- **High pressure rating at low cost**
- **High resistance to flex and vibrational fatigue**
- **Mechanically strong—resists abrasion and impact**
- **Corrosion and chemical resistance**
- **Serves wide temperature range: as low as −100°F., up to +225°F.**
- **Will not embrittle in storage**

• Available in two short time burst pressure ratings—1000 psi (Type T) and 2500 psi (Type H) O.D. sizes ⅛", 3/16", ¼", 5/16", ⅜".

Information on characteristics, properties, applications, tubing accessories and installation tools is outlined in new NYLAFLOW Bulletin. Write for your copy today.

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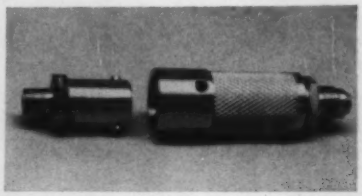


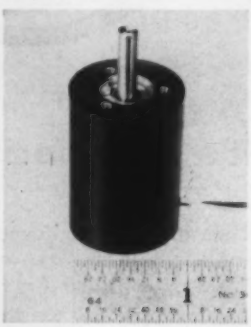
vent lines. It operates freely with either liquid oxygen or nitrogen at temperatures from −320 to 110 F. Visual aids are provided to determine when unit is in locked position. Constructed of corrosion-resistant materials, coupling incorporates Teflon or Kel-F seals. Unit can be connected or disconnected with one-hand operation. There is no external leakage on connection. One type is self-sealed when disconnected. **Essex Mfg. Co. Inc.**, 8213 Gravois Ave., St. Louis 23, Mo. I

Circle 670 on Page 19

Miniature Motors

drive cooling fans and blowers

Miniature 1-in. diam motors, designed for one, two, or three-phase, 400-cycle operation, drive cooling fans and blowers. They are intended for use in high-tempera-



ture ambients, and have many applications. **Air-Marine Motors Inc.**, 369 Bayview Ave., Amityville, L. I., N. Y. D

Circle 671 on Page 19

Liquid Epoxy Resins

for electrical, chemical, plastic, and other industries

Three basic liquid epoxy resins are for use in the tooling, electrical, paint, adhesive, reinforced plastic, and chemical industries. Resin 332 is water-clear, extremely uniform, and has low viscosity. Resin 331

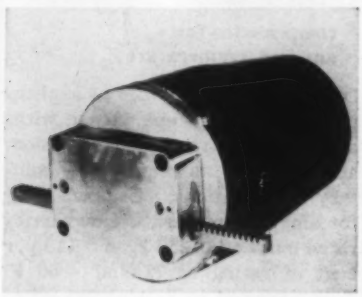
is a standard unmodified resin suitable for use in tooling, casting, adhesives, and electrical component encapsulating. Resin 334 is a modified low-viscosity resin which is especially suited for laminating. **Dow Chemical Co.**, Midland, Mich. H

Circle 672 on Page 19

Linear Actuator

for proportional position control

Lineatrol linear actuator is for nuclear control, machine-tool control, and other positioning applications where linear motion must be proportional to a control signal. It



consists of a gearmotor with built-in potentiometer to produce a remote indication of position, or for use in automatic-control circuits. With precision multiturn potentiometers, positioning accuracies of ±0.004 in. are provided for a 10-in. stroke, with greater accuracies provided for shorter strokes. Output is through precision rack and pinion with thrust forces to 1000 lb and with a variety of stroke lengths and stroking rates. Unit can be face, bracket, foot, or pivot-mounted. **Jordan Co.**, 3235 W. Hampton Ave., Milwaukee 9, Wis. K

Circle 673 on Page 19

Miniature Dial Timer

incorporates reversible motor

Series 306 Duo-Set timer controls two independently adjusted load circuits for off-on cycling over entire dial range, without limitation of settings within timer range. Synchronous, reversible motor drives elapsed-time indicator up and down scale to setting pointers. Reversal is smooth and silent,

design with IR compressors to assure Minimum Maintenance

One of the strongest sales points you can design into your air-operated equipment is the dependability and efficiency of the air supply.

Ingersoll-Rand air compressors are engineered with proven features that will give longer trouble-free operation—*reducing* costly maintenance and excessive downtime.

Bare, baseplate or receiver mounted air compressors can be supplied to meet your specific requirements.

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11 Broadway, New York 4, N.Y.

air-cooled compressors —½ through 20 horsepower

Other compressors to 6000 horsepower

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"Continue to use Morganite!"

TYPICAL TEST REPORT SHOWS MORGANITE OUTLASTS OTHER MOLD MATERIALS 7 TO 1!

No. 714A

"During the past 12 months, 1050 regular molds were used on the large jobs at considerable cost. These molds had an average life of 2½ hrs. on the machines for a total of 2625 hours. In the same number of hours, only 175 Morganite molds (average life 15 hours) are needed at a fraction of the cost. Substantial savings in less down time also realized. Due to mold changes, when using Morganite, another savings would be realized by saving ware now lost during such changes.

Morganite ordered for use on all future runs."

Signed (Name on request)
Chief Test Engineer

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JET ENGINE PUMP VANE

MORGANITE CURRENT COLLECTOR

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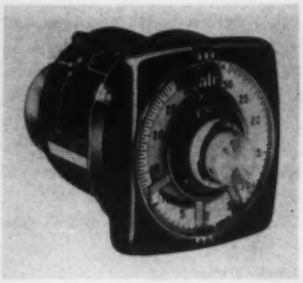
Circle 516 on Page 19



without springs, solenoids, ratchets, or pawls. Unit can be mounted in any position. **Automatic Timing & Controls Inc.**, King of Prussia, Pa. E

Circle 674 on Page 19

Circuit Breaker

compensates for ambient temperature

D6752-5 circuit breaker is a push-pull, indicating type which withstands shock, vibration, corrosion, and humidity as required by military specifications. Compensating for ambient temperature, it carries rated current at 250 F, and 115 per cent of rating at 77 and −60 F. It is designed to trip at not more than 138 per cent at 250 F, 138 per cent at 77 F, and 160 per cent

at −60 F. Maximum weight is 0.2 lb. **Spencer Thermostat Div., Metals & Controls Corp.**, Forest Street, Attleboro, Mass. B

Circle 675 on Page 19

Self-Adhesive Felt

is cut in a variety of shapes and sizes

Quik-Felt is used for sealing, cushioning, spacing, insulating, and protecting parts in maintenance and production work. It adheres to glass, ceramic, wood, metal, and plastics with finger pressure. Felt is precut in a variety of thick-

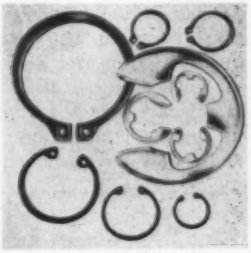
nesses, shapes, and sizes, mounted on dispensable cards and liners. It is also available in 90-ft rolls in widths from 5/32 to 2 in. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 676 on Page 19

Retaining Rings

in a variety of metals and sizes to 2 in.

Circolox retaining rings are available in three types: Internal ring with lugs on inside of ring; ex-



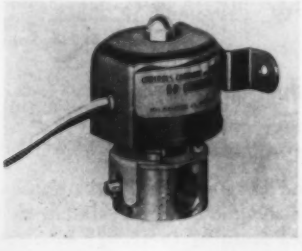
ternal ring with lugs on outside of ring; standardized E-ring for shoulders on small shafts. Units are of steel, stainless steel, phosphor bronze, and beryllium copper. Steel rings are offered with cadmium plating, zinc plating, Parkerized coating, blued steel, and black oxide coating. Rings conform to all required standards. **Ramsey Corp.**, 3691 Forest Park Blvd., St. Louis 8, Mo. I

Circle 677 on Page 19

Solenoid Valve

normally closed unit is for use in small areas

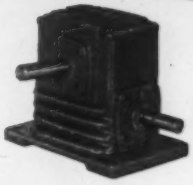
Model 291 two-way solenoid valve can be used for air, gas, water, oil, and all common industrial fluids. It is designed for use in tight equipment corners and crevices, wherever a compact, normally closed valve is needed to control flow. Unit can be mounted in any posi-



OHIO GEAR'S

New Line Of Fin Cooled

SPEED REDUCERS



Model: S-20

Model: U-20

Model: P-20

. . . handle heavier loads

. . . take less space

- Fin Cooling
- New Rugged Housings
- Smaller Size To Capacity Ratio
- Heavier Bearings
- Versatile Range of Speeds And Sizes

● These OHIO Reducers represent a new standard for rugged, compact power transmission. Called the "Series 20", the new models are available in a wide variety of capacities with reduction ratios from 9:1 through 58:1, and for speeds up to 1850 RPM. All models in the new line feature fin cooling to permit handling heavier loads in less space.

Ask your local OHIO Distributor for complete details, or write for the new OHIO catalog.

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186 pages of engineering data, size and selection charts on speed reducers, gears and sprockets. Send for your free copy today!

Manufacturers of gears and speed reducers - both stock and special

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Circle 517 on Page 19

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Bulk or Fabricated Parts

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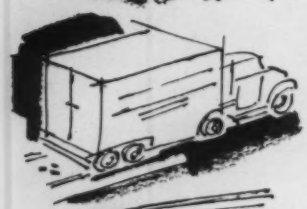

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INSTALLATIONS ARE CHECKED—At Cambridge, orders aren't filled and forgotten. Our own sales engineers follow up your order to make sure our product is giving you the best possible service.

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WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

tion. Applications include vending machines, water softeners, humidifiers, automatic machinery, and welding equipment. **A-P Controls Inc.**, 2450 N. 32nd St., Milwaukee 45, Wis. K

Circle 678 on Page 19

Snap-Action Switches

have low actuating force

Snap-action, neutral-position switches, available in three models, provide two isolated circuits with double-break contact arrangements. Actuating force is 125 oz-in. to trip and 190 oz-in. for full overtravel. Release force is 38 oz-in. Models operate when actuated 5 deg in either direction from neutral. They are provided with

70-deg safety overtravel in both directions. Model L100WNS is normally open in neutral position. Clockwise operation closes one circuit and counterclockwise operation closes other circuit by snap action, with spring return to normal from either direction of operation. Model L100WNR provides spring return to neutral from clockwise operation. Model L100WNL provides spring return to neutral from counterclockwise operation and maintained contact in clockwise position. **R. B. Denison Mfg. Co.** 102 St. Clair Ave. N. W., Cleveland 13, Ohio. F

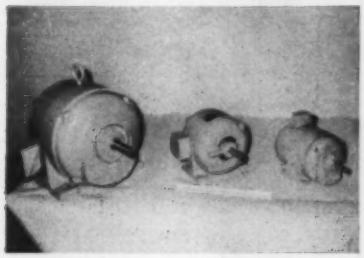
Circle 679 on Page 19

Induction Motors

for continuous-duty, 40-C rating

Line of 400-cycle, three-phase induction motors is available in ten sizes from ¾ to 15 hp, with speed

ratings of 3850, 3320, 2580, and 1880 rpm. Motors are designed for continuous-duty, 40-C rating. They provide slow speeds, without gearing, and can be used for a variety



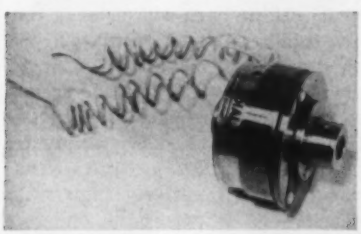
of applications in electronic, radar, metering, and other installations. Standard construction is open or open-dripproof, but totally enclosed units can be furnished. **B. A. Wesche Electric Co.**, 9027 Shell Rd., Cincinnati 42, Ohio. G

Circle 680 on Page 19

Magnetic Clutch

delivers 7 lb-in. minimum torque

Model SAC 181 magnetic clutch incorporates a stationary armature, eliminating the need for slip rings and brushes. New friction facing of poleshoe assures smooth, sensitive torque control. Flexible-membrane poleshoe assembly provides a torsionally rigid unit with zero backlash and zero residual drag, and allows angular misalignment to 3 deg between driving and driven shafts. Rated to deliver a



minimum torque of 7 lb-in. at full power, clutch has power consumption under 4 w. **Dial Products Co.**, 9 Avenue E, Bayonne, N. J. D

Circle 681 on Page 19

Sealing-Type Fasteners

conform to curved surfaces

Spin-Seal sealing-type fasteners provide a secure triple seal on irregular, corrugated, or curved sur-

DESIGN HISTORY IS BEING MADE

by modern gray & ductile iron castings!

Block link for chain redesigned to a ductile iron casting eliminated 20 operations, and saved $42,000 in equipment.
The Jeffrey Manufacturing Co.
Changing this compressor discharge casing to a high strength gray iron casting saved 58% in material and 34% in machining costs.
General Electric Company
A cost reduction of up to $20 a set was made by using ductile iron to make these wing-form bodymakers.
National Can Corporation
This oil pump spacer when converted to cast iron eliminated carburizing and finishing operations and saved 88%.
Detroit Diesel Engine Division, GMC.

Four Winners 1957 GIFS Contest

Almost every day design history is being made by gray and ductile iron castings! Modern metallurgy is providing gray irons with new highs in properties . . . new molding techniques are producing castings with better surface finish and closer dimensional accuracy. Such outstanding developments are causing engineers to consider gray and ductile iron *first* in designing products. Write for the GRAY IRON CASTINGS HANDBOOK. Save money by learning more about this remarkable material.

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TIME TO DESIGN WITH **GRAY IRON CASTINGS**

Circle 519 on Page 19

On North American's F-100 Super Sabre...

Delron Fasco SPACERS

SAVE WEIGHT & INSTALLATION TIME!

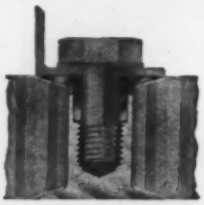
Backbone of our nation's air superiority, F-100 Super Sabre is the first supersonic fighter-bomber to go into mass production.

North American's advanced engineering research is constantly developing new techniques for honeycomb panel construction and fastening methods.

On the F-100, FASCO Spacers provide a lighter-weight, more economical method of attaching structure and equipment to honeycomb panels. Simple, two-piece design and easy installation with ordinary tools, make FASCO Spacers the best bet for efficient honeycomb panel fastening.

Write for engineering information about this and other applications of FASCO Spacers which may help solve your critical fastening problems!

Lightweight, high column strength aluminum or stainless steel FASCO Spacers are available in a variety of designs.

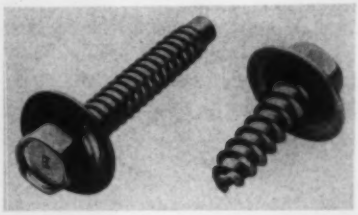


FASCO Threaded Self-Locking Spacer is specified for honeycomb panels of North American's F-100 Super Sabre.

This is another example of how Delron Products solve the critical fastening problems of industry!

THE DELRON COMPANY, INC.

5224 SOUTHERN AVENUE • SOUTH GATE, CALIFORNIA • LORain 7-2477



faces as well as flat surfaces. They consist of a spring-type hardened washer with permanent flowed-in gasket sealant, preassembled to any standard machine screw, cap screw, or bolt. Applications include weather-sealing of metal siding and roofing of buildings, auto and truck body assembly, outdoor telephone booths, kitchen and laundry appliances, air conditioners, boats, and similar products. Service temperatures from −100 to 250 F can be withstood. Fasteners are available in screw sizes from No. 6 to ½ in., with washers from 0.560 to 0.920-in. in diam. Units are carbon or stainless steel. **Russell, Burdsall & Ward Bolt & Nut Co.**, 100 Midland Ave., Port Chester, N. Y.

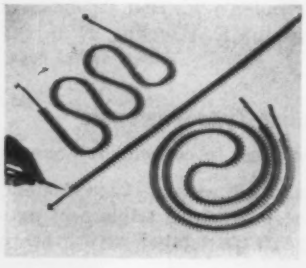
D

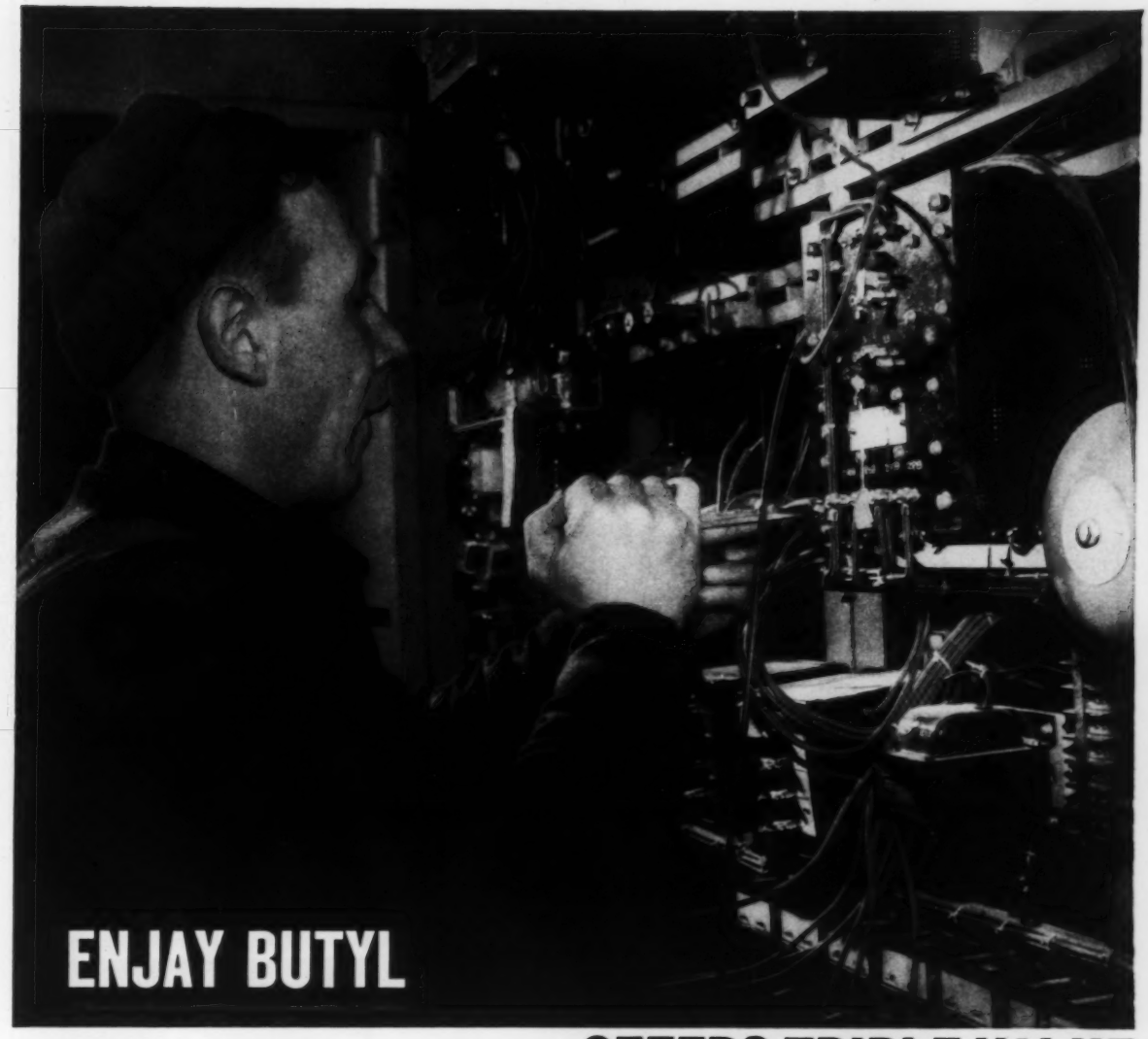
Circle 682 on Page 19

Tubular Heating Element

for forced-convection air heating

Chromalox Microfin is a slim, finned tubular heating element for forced-convection air heating. It provides rapid heat-up almost identical with an open-coil element, but has totally enclosed, insulated construction. Element is ¼ in. in diam and fins are furnace-brazed to provide homogeneous construction. Unit is suited for air ducts, blower-type space heaters, ovens, and dryers. Relatively high watt density—80 w per sq in. on steel or alloy sheath—permits concentration of output where space is at





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Pioneer in Petrochemicals

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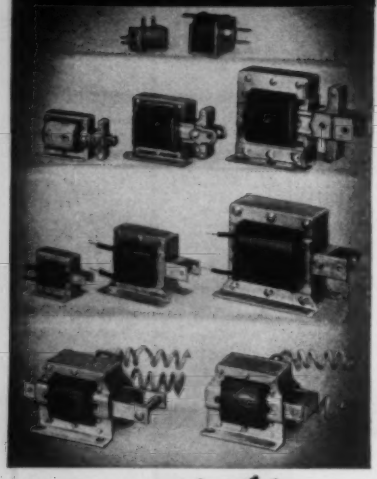
Circle 521 on Page 19

DORMEYER
CUSTOM QUALITY STOCK SOLENOIDS



available for immediate delivery

The line consists of 17 models to provide 34 widely differing specifications . . . delivery can be made within 24 hours of receipt of order . . . specifications include: pull and/or push capacities up to 45 lbs., . . . sizes from ¾"x 1⅛" to 3"x 3". . . stroke lengths fractional to 2".

All solenoids are built to rigid standards of highest custom quality. Double shading coils provide high sealed pull without excessive AC hum. Electrical characteristics are thoroughly uniform. Units are compactly engineered to extremely close tolerances. Rugged construction provides long service-life under the most strenuous conditions.

All solenoids in the line can be supplied in any quantity from single units to long-run cost-saving production orders.

Request complete information. Ask for catalog.

DORMEYER INDUSTRIES

3434 N. Milwaukee Avenue, Chicago 41, Illinois

Circle 522 on Page 19

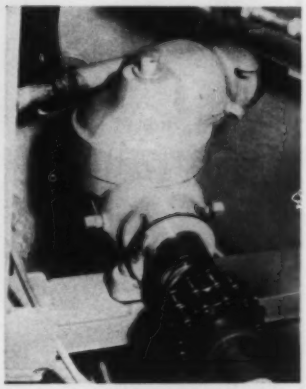
a premium. Radiating capacity of fins also permits application where low surface temperatures are required. Standard heated lengths range from 5½ to 47½ in. Voltages are 120 and 240, with wattages from 525 to 3000. **Edwin L. Wiegand Co.**, 7500 Thomas Blvd., Pittsburgh 8, Pa. G

Circle 683 on Page 19

Geared Joint

transmits power through any angle to 300 deg

Geared joint, actually a swivel-gear box, transmits power by a system of bevel gears. Joint transmits power at any angle through



300 deg. Size 160, shown, has maximum rating of 200 lb-in. torque. **Stow Mfg. Co.**, 11 Shear St., Binghamton, N. Y. D

Circle 684 on Page 19

Connecting Leads

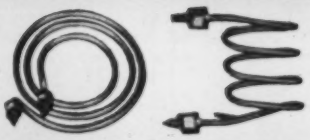
withstand 20-lb tensile force

Biaxial Addaplug connecting leads are for general-purpose hookup and interconnection of equipment, instrumentation work, breadboards, and servo setups. Design, with side holes and stacking feature, permits unlimited connections at any plug body. Spring-action tip is self-wiping and insures good connection with uniform, low-contact resistance of less than 0.001 ohm. Tip, which compensates for wide variations, mates perfectly with random-size female connections. Lead is flexible stranded wire, polyvinyl insulated, and integrally molded to plug. Units withstand tensile force of at least 20 lb and

Solve Your
HOT PROBLEMS
with
VULCAN VERSATILITY
in

. . . CARTRIDGE HEATERS

. . . STRIP HEATERS



. . . TUBULAR HEATERS

. . . IMMERSION HEATERS

When you have hot problems in electric heat, you get a speedy solution through *Vulcan Versatility* — in design, engineering and manufacturing. Complete line includes finned, ring, band and pressuring heaters. All elements are available in a wide variety of sizes, wattage and voltage ratings, sheath materials, lead wires and terminals.

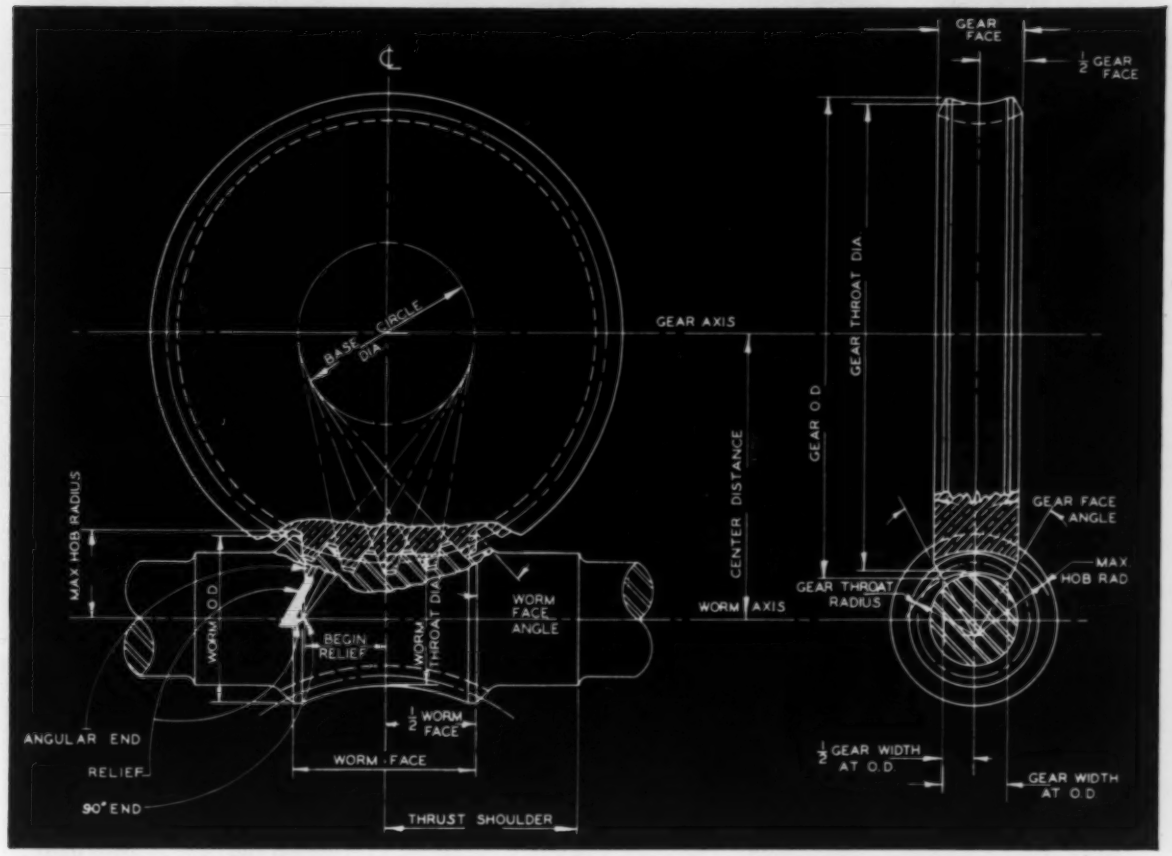
Write for catalog

VULCAN
ELECTRIC COMPANY
DANVERS 6, MASS.

Cartridge Heaters • Strip • Tubular • Immersion Electric • Soldering and Branding Irons Solder and Glue Pots

Circle 523 on Page 19

WORM GEAR DESIGN... *Bulletin #200*



Bulletin 200 has 20 pages crammed with 38 formulae, such as the Formula for Class I AGMA Horsepower Rating:

$$P = K_s K_m K_v \frac{n}{mg}$$

Step-by-step instructions, with typical examples, enable you to quickly determine the size worm gearset you need to meet any horsepower and service required.

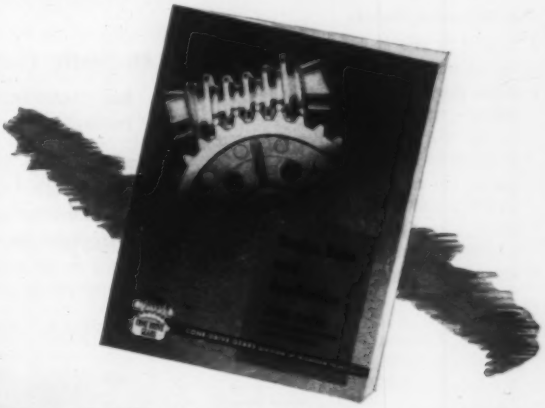
You can calculate the bearing loads and sizes needed for the worm and gear shafts.

You can check the worm root stress and gear tooth stress.

Efficiency is charted against helix angle with modifications for required speed so you can quickly determine efficiency.

One quick look at the drawing above will convince even the uninitiated that no other worm gearset has so many teeth in contact. No other worm gearset is so simple to design and rate. No other worm gearset will carry so much load in so little space with so little weight.

Now, Bulletin 200 provides complete design and application data on space-saving double-enveloping worm gearing. Ask for it without obligation.



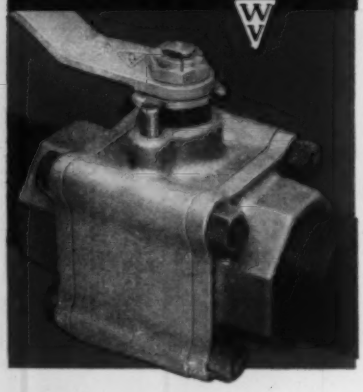
CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS | DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS | DOUBLE REDUCTION WORM GEAR SPEED REDUCERS | DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

Circle 524 on Page 19

Econ-O-"Miser"



Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

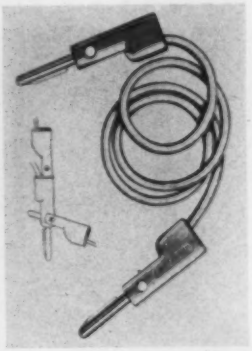
* Pat. Pending

Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

Circle 525 on Page 19



resist failure due to flexing at junction of plug and wire. They fit all standard terminal posts, jacks, alligator clips, and spade lugs. Six standard colors are available. **Associated Engineering Corp.**, 65 Kent St., Brookline 46, Mass. B

Circle 685 on Page 19

Vinyl Dispersion Resin

has high electrical quality and low water absorption

Pliovic VO is a polyvinyl-chloride dispersion resin developed for plastisol and organosol applications such as in wire coating, cable covering, and potting compounds, in rotational molding operations, and decorative and protective metal coatings. Containing only minor fractions of nonpolymer, material has high electrical quality and low water absorption. It is packaged in 50-lb bags. **Chemical Div., Goodyear Tire & Rubber Co.**, Akron 16, Ohio. F

Circle 686 on Page 19

Magnetic Clutch

has clutching torque rating of 16 oz-in.

Model D-103 is a size 11 single-ended, magnetically actuated clutch with diameter of 1.062 in. Clutching torque is rated at 16 oz-in., with 3 w dc applied to control coil. Concentric input and output shafts

(Advertisement)

Value Analysis On Fasteners and Small Parts

Shows Cold Heading Usually Cuts Costs

This may well be the age of "Value Analysis". And, one of the most promising fields for such a cost saving study is fasteners and small parts. Actually one of the most important cost cutting developments in recent years is the increasing use of cold headed parts and fasteners in place of more expensive and structurally weaker screw machine products.

The more expensive bar stock used in the screw machine method results in considerable waste, whereas the waste is almost negligible in cold heading.

Another important consideration is the greater strength structure of parts made by the cold heading method. The blow of the heading tool causes the grain structure of the metal to flow in lines of greater strength.

The possibilities of cold heading are almost unlimited when used in conjunction with secondary operations. The tremendous savings in operation and material costs make it a must consideration when designing small parts either as fasteners or as integral units for manufactured parts. It has been a long time policy of John Hassall, Inc. to support their cold heading equipment with the latest methods of secondary manufacture. Machines for roll threading, slotting, drilling, tapping and many other operations are available for your profit.

Given complete specifications, including a drawing and an idea of the application, we can quickly tell you whether or not it will be advantageous to have your fastener or part JOB-DESIGNED by HASSALL. The remaining important aspect of our service to you is the ability to get into production quickly and make prompt shipment.

Write today for your copy of our new Catalog No. 106.

John Hassall, Inc.

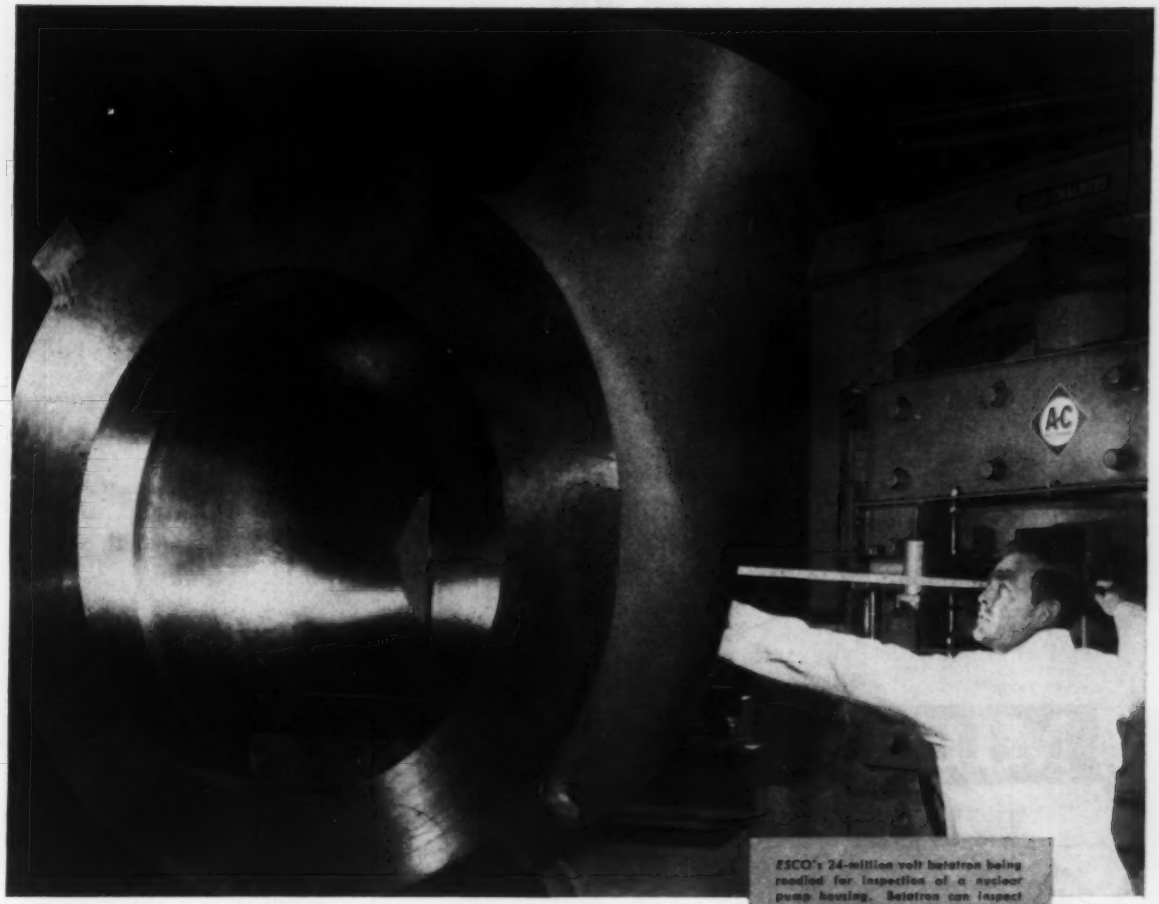
P. O. Box 2197

Westbury, Long Island, New York

Manufacturers Since 1850

See us at the Design Engineering Show

Circle 526 on Page 19



ESCO's 24-million volt betatron being readied for inspection of a nuclear pump housing. Betatron can inspect a six-inch steel wall section in 60 seconds, a 16-inch wall in 1½ hours.

design problems can be simplified with

ESCO'S nuclear casting know-how

Solving tough casting problems has always been *ESCO*'s specialty. And that's why *ESCO* has been furnishing nuclear castings right from the start of the atomic energy program. Nuclear casting specifications and inspection requirements are thoroughly understood at *ESCO*.

ESCO has the facilities, as well as the technical know-how, for critical, exacting, casting jobs. Centrifugal, shell or static casting methods produce castings weighing several tons, or less than a pound, in more than 90 steel alloys. Testing facilities include X-ray, gamma ray, spectrograph, zyglo, dye penetrant, magnetic particle and betatron inspection, as well as complete chemical and mechanical laboratories.

Make an appointment with an *ESCO* metallurgical engineer today. He may be able to simplify and help solve your designing problems.

ESCO

ELECTRIC STEEL FOUNDRY COMPANY

2183 N. W. 25TH AVE. • PORTLAND 10, OREGON

MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

Circle 527 on Page 19

THERE MUST BE AN EASIER WAY

—AND THERE IS WITH . . .

MIDLAND

WELDING NUTS

The Midland Steel Products Company is constantly developing new, progressive ideas to improve the efficiency of its fine products. It pioneered the *Midland Welding Nut,* for example, and so successful was this application in its own shops that this labor-saving device has been made available to others.

If you are a manufacturer of metal parts or products and have fastening, fabricating or assembling problems, you may find Midland Welding Nuts just the solution you've been looking for. The Nuts are easily welded into position for the lifetime of the product. You can be assured of correct fit, even in the most awkward, hard-to-reach places. Bolts turn easily into the applied nuts. Thus, heretofore two-man operations can be handled by one man in most instances. Weld-nut equipped parts will be preferred by your customers for they will find them cost-saving and trouble-free, cutting down assembly time. Too, you can be sure that your parts will be properly assembled without the risk of rattles.

A few minutes' time in checking the assembly problems of your customers will be profitable to you. Midland Welding Nuts are low in cost, can give you a definite advantage over competition. This practical application is recognized internationally and endorsed by many designers of the finest products.

MIDLAND-ROSS CORPORATION

Executive Offices: Cleveland 1, Ohio

Formerly THE MIDLAND STEEL PRODUCTS COMPANY

Cleveland • Detroit • Owosso, Michigan

And J. O. ROSS ENGINEERING CORPORATION

New York City, N. Y.

Including John Waldron Corporation • Midwest Piping Corporation • Ross Engineering of Canada, Limited

Andrews & Goodrich, Incorporated

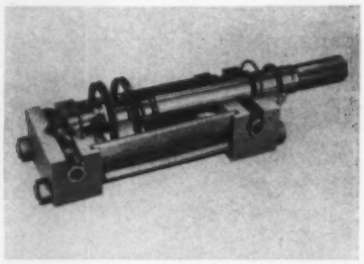
Circle 528 on Page 19

are located at the synchro-mount end of the unit. Flat-faced couplings have minimum angular displacement upon engagement. Voltage ratings range from 1.5 to 300 v dc, with 24 v standard. High-temperature lubrication and insulation can be incorporated to achieve high performance under Class H temperatures. **Dynamic Instrument Corp.,** 59 New York Ave., Westbury, L. I., N. Y. D

Circle 687 on Page 19

Cylinders

have bore sizes from 1½ to 8 in.



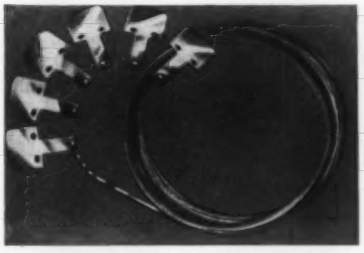
Series S2 air and hydraulic cylinders for heavy-duty service meet automotive industry automation standards. They are rated at 1000 psi hydraulic, 200 psi air, and for nonshock load to 1500 psi hydraulic. Nine bore sizes from 1½ to 8 in. are available in 11 standard mountings. Two piston designs are available—a standard high-tensile cast-iron piston, and an alloy step-cut piston-ring piston. Both pistons are piloted to the rod and locked positively with self-locking nut. **Hydro-Line Mfg. Co.,** 5600 Pike Rd., Rockford, Ill. K

Circle 688 on Page 19

Electrical Contact Tapes

are silver-cadmium oxide clad

Use of silver-cadmium oxide clad electrical contact material, formed as a continuous coil of tape, permits design of lower cost contacts. It makes possible automatic assembly of complex intricate designs, shapes, materials, support and base-metal backings. Tape contact material is preformed to finished cross-sectional shapes, maintaining these shapes after assembly. To facilitate welding, tapes are supplied with various types of



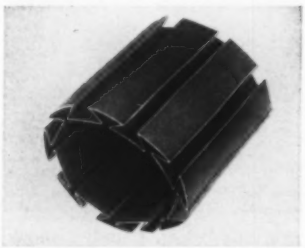
projections, the most common being a knurled type. **General Plate Div., Metals & Controls Corp.,** Forest Street, Attleboro, Mass. B

Circle 689 on Page 19

Tube Shield Insert

contacts more than 95 per cent of tube envelope

Full-contact insert for miniature tube shields is designed with oppositely oriented triangles which provide almost complete contact with tube envelope. More than 95 per cent of cylindrical surface area of tube envelope is contacted, permitting lower bulb temperatures. Design provides adjustment to wide variation in tube and shield diameters. Spring quality provides excellent cushioning for tube under extreme shock and vibration. Of Ebonol C finished, heat-treated



beryllium copper, insert is available in widths to 1½ in. Units can be obtained in 36-in. strips or cut to length to fit any standard tube shield. **Atlas E-E Corp.,** 47 Prospect St., Woburn, Mass. B

Circle 690 on Page 19

Fractional-Horsepower Motors

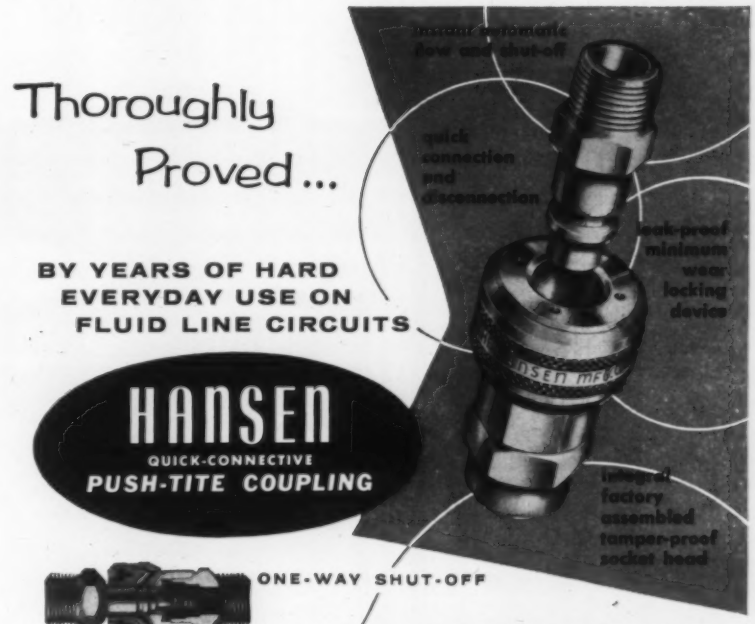
for high-temperature applications

New subfractional-horsepower motors incorporate cooling body fins for high-temperature applications. Standard frame is encased in a heat-radiating aluminum shell,

Thoroughly Proved...

BY YEARS OF HARD EVERYDAY USE ON FLUID LINE CIRCUITS

HANSEN
QUICK-CONNECTIVE
PUSH-TITE COUPLING


quick connection and disconnection
leak-proof minimum wear locking device
factory assembled tamper-proof socket head
HANSEN MFG.

ONE-WAY SHUT-OFF

Locking pins in Hansen Push-Tite Coupling Socket afford large area contact with Plug, thereby preventing wear and subsequent leakage.

● The ability of Hansen Push-Tite Couplings to withstand severe service—with practically no maintenance—has been thoroughly proved by years of hard, everyday use on hundreds of fluid line circuits. The "socket head", which contains the locking device, is factory assembled into a rugged integral unit which cannot be readily injured or have component parts lost by casual tampering.

To connect the Coupling, you merely push the Plug into the Socket with one hand. Flow is instantaneous. To disconnect, push back sleeve on Socket—Coupling disconnects. Flow is shut off instantly and automatically.

QUICK-CONNECTIVE FLUID LINE COUPLINGS for

AIR
OIL
GREASE
HYDRAULIC FLUIDS
WATER
VACUUM
STEAM
OXYGEN
ACETYLENE
REFRIGERANTS
GASOLINE
COOLANTS
L-P GAS

★

REPRESENTATIVES IN PRINCIPAL CITIES

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for Steam, Oxygen, Acetylene, etc.

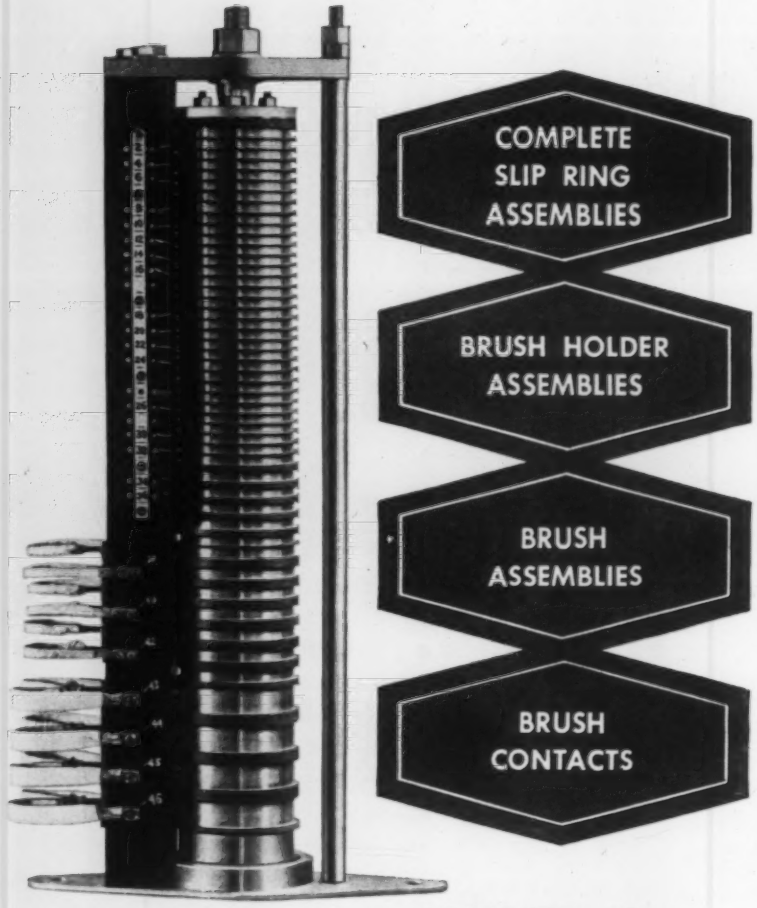
SINCE 1915

QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

Circle 529 on Page 19



ONE OR ALL—

Created and Completed by Superior in their entirety

All phases of slip ring design and manufacture are covered by the Superior staff within the Superior plant. Slip rings can be (1) engineered and built to fit your application, or (2) made to your own design. There is practically no limitation as to size.

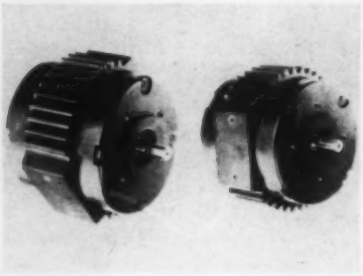
A long and far-reaching experience in the manufacture of brush contacts has speeded Superior's entry and broad-based service in the field of slip ring assemblies.

Write for Bulletin S-2056, sketching Superior's background in this broadening, highly technical field.

Superior CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

ribbed with deep-troughed cooling fins. Integral mounting pads, 180 deg apart, provide for optional face or body mounting. New cooling shell withstands greater shock and



vibrational stresses, and permits use in high-temperature applications. **Air-Marine Motors Inc.**, 369 Bayview Ave., Amityville, L. I., N. Y. D

Circle 691 on Page 19

Pillow Block

for use in temperatures to 650 F

Size B self-aligning pillow block is designed to run dry or submerged in any fluid that will not corrode cadmium-plated steel housing. It can be used in temperatures to 650 F. Unit is for use with shaft diameters from $\frac{3}{4}$ to $1\frac{1}{2}$ in., and

should not be used under shock or severe vibration. **Electro-Nite Carbon Co.**, 8601 Torresdale Ave., Philadelphia 36, Pa. E

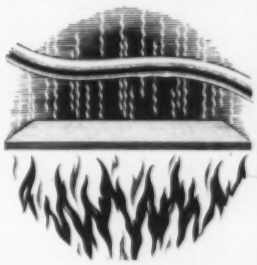
Circle 692 on Page 19

Accelerometer

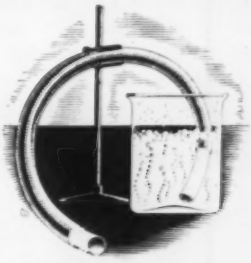
has self-contained calibration system

Applications of Model ADT-905 differential-transformer accelerometer include control and guidance in aircraft and missiles, fire control, servo guidance, and pitch and yaw correction characteristics. Unit is equipped with self-contained calibration system which checks its operation while in use, or calibrates

If your HOSE LINES must cope with these conditions...

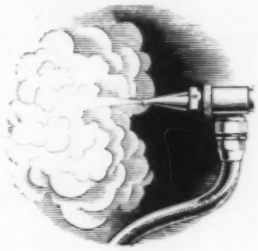


HIGH TEMPERATURES

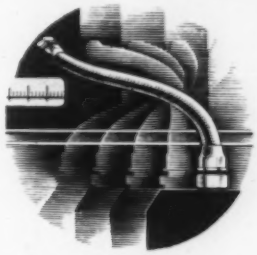


CORROSIVE CHEMICALS

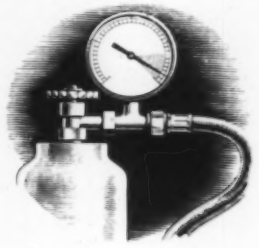
ADHESIVES



LIVE STEAM



FLEXING AND IMPULSING



HIGH PRESSURES

you can cut costs, increase reliability with hose made of TEFLON® TFE-fluorocarbon resins

Hose lined with TEFLON TFE-fluorocarbon resin is being specified for the toughest jobs, *because:* TFE resins are unaffected by practically all corrosive chemicals and solvents. They can take continuous operating temperatures up to 500°F. . . . remain tough and flexible in extreme cold. They have excellent endurance under severe conditions of impulsing and vibration. Handle live steam without failure. Repel adhesion of sticky or viscous substances . . . reduce possibility of contamination. Available with either permanent or reusable couplings.

Discover how hose lined with TFE-fluorocarbon resin can cut your maintenance and downtime losses. See your hose supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Room 2420, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed here.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Circle 531 on Page 19

it statically or dynamically. Accelerometer is inherently stable over temperature range of −65 to 250 F. Unit has natural frequency of approximately 30 cps. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J. D

Circle 693 on Page 19

Aluminum-Oxide Ceramic

has tensile strength of 34,000 psi

Nonporous, 99 per cent aluminum-oxide ceramic, designated AD-99, has superior physical strength, even at high temperatures, and low dielectric loss. Material has tensile strength of 34,000 psi, and retains 75 per cent of tensile strength at temperature of 2000 F, with strength of 20,000 psi. It has excellent hardness and wear resistance, high density, and fine crystal size. Material has many electronic and mechanical applications, such as in the manufacture of vacuum-tube envelopes, high-temperature bearings, and gage blocks. **Coors Porcelain Co.**, 774 Ninth St., Golden, Colo. K

Circle 694 on Page 19

Metal Film Resistors

withstand full load at 125 C temperature

Molded metal film resistors are available in five sizes from ⅛ to 2 w. They provide high stability with low controlled temperature coefficients, and withstand full load at 125 C ambient temperature. Units have a metallic resistive film firmly bonded to a ceramic core. Resistors are for applications where high reliability and low controlled temperature coefficient are required, for applications requiring low inductance and/or shunt capacitance, and for applications where size of precision wire-wound resistors is not tolerable. **International Resistance Co.**, 401 N. Broad St., Philadelphia 8, Pa. E

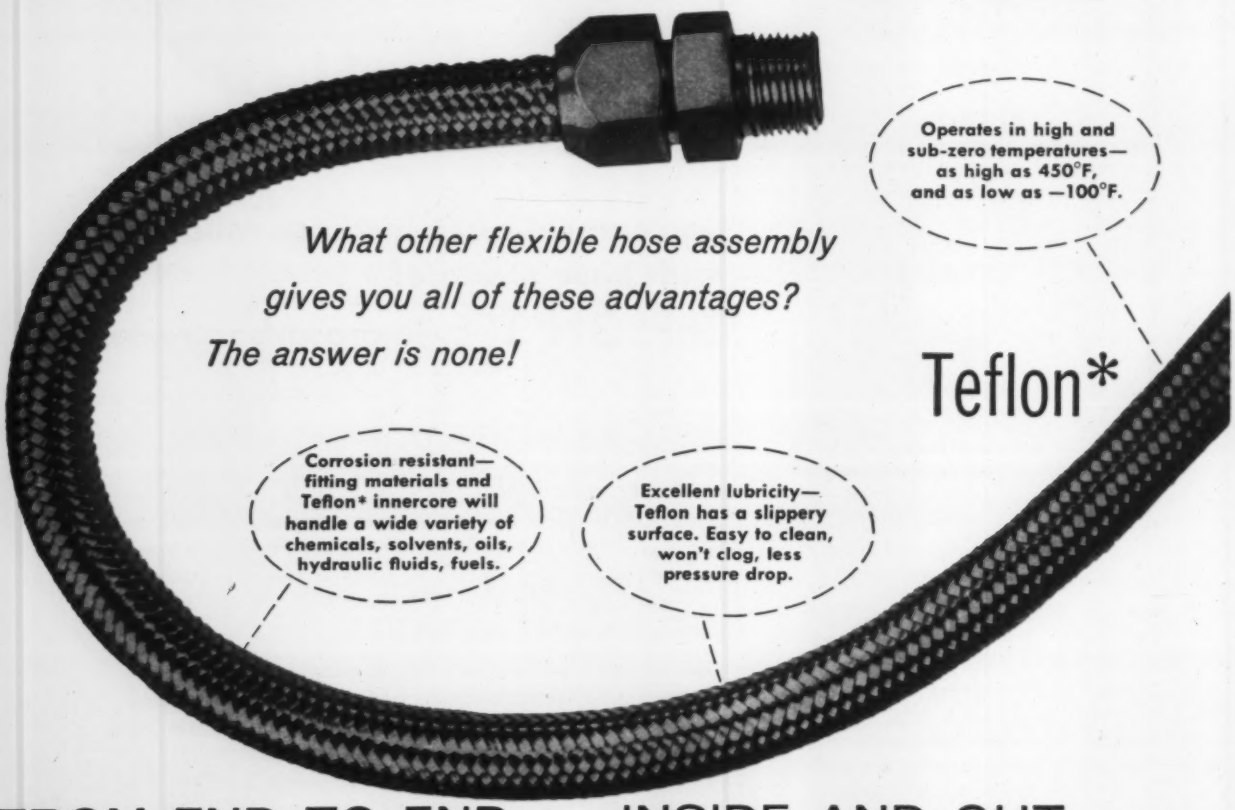
Circle 695 on Page 19

Solenoid Valve

for temperatures from −40 to 180 F

L Series solenoid valve permits full flow of air, water, oil, and other common media. It is a two-way, normally closed, pilot-operated unit. Only 3 31/32 in. high, valve provides full ½-in. orifice with either ⅜ or ½-in. pipe taps. Pressures range from 5 to 150 psi and

temperatures from −40 to 180 F. Valve can operate in any position,


Operates in high and sub-zero temperatures—as high as 450°F, and as low as −100°F.
What other flexible hose assembly gives you all of these advantages?
The answer is none!
Teflon*
Corrosion resistant—fitting materials and Teflon* innercore will handle a wide variety of chemicals, solvents, oils, hydraulic fluids, fuels.
Excellent lubricity—Teflon has a slippery surface. Easy to clean, won't clog, less pressure drop.

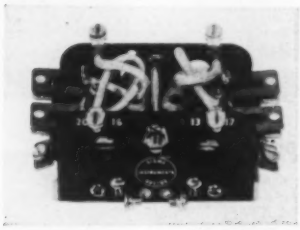
FROM END TO END . . . INSIDE AND OUT

and can be mounted directly to a line. Dept. L141, **Skinner Electric Valve Div., Skinner Chuck Co.,** 105 Edgewood Ave., New Britain, Conn. B

Circle 696 on Page 19

Polarized Power Relay

incorporates permanent magnet latch



Series 61 dc polarized relay is designed to switch 1 to 2-kw loads in response to momentary ¼ to ½-w signals. Relay incorporates a permanent magnet latch which eliminates all but one moving part and increases resistance to shock and vibration. Applications include machine control panels and battery-energized control systems. Unit is a double-pole, double-throw relay with four separate contact circuits. Nominal contact rating is 20 amp resistive at 28 v dc or 120 v ac, with standard sensitivities of 225 or 450 mw. **Sigma Instruments Inc.,** 48 Pearl St., South Braintree 85, Mass. B

Circle 697 on Page 19

Precision-Rolled Strip

of precious metals clad permanently to base metals

For use in the electronic, electrical, chemical, aircraft, instrumentation, automation, and related industries, precious metals permanently clad to inexpensive base metals are available in precision-rolled strip form. Metals clad include silver, gold, platinum, and palladium. Cladding is accomplished by direct bonding of ultra-thin layers of the precious metal to the base metal by heat and pressure. Bonded structure exhibits properties of both metals. Industrial uses include radar-cable braiding, high-temperature coils, high-frequency conductors, current-carrying springs, electrical contacts, and grids for vacuum tubes. **American Silver Co.,** 36-07 Prince St., Flushing 54, N. Y. D

Circle 698 on Page 19

Conduit Connector

liquid-tight unit has insulated throat

New conduit connector protects conductors from abrasion at termination points in liquid-tight flexible conduit and facilitates wire pulling. Insulated throat covers edges of connector to provide a smooth path for conductor while it is being pulled through connector. Built into connector end.

Titeflex
Springfield
"140"
The Teflon innercore makes Springfield "140" hose assemblies extremely flexible. Long fatigue life.

Hose Assemblies with Reusable Fittings

Springfield "140" Teflon Hose Assemblies are approved for 1500 psi systems. Nominal hose diameter ¼" to ¾". Male pipe and J I C female swivel fittings available from stock.

In which of these applications can you use Titeflex Teflon?

- Acid handling
- Hot waxes and fats
- Liquid adhesives
- Silicone oils
- Chemical processing
- Food and beverage processing
- Steam lines
- Hydrogen peroxide
- Hot lacquers and enamels

Look in the yellow pages of your directory for the Titeflex distributor nearest you, or write direct for Titeflex Springfield "140" Catalog Supplement

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD, MASS.

Long life—Springfield "140" is unaffected by aging. Shelf life is practically unlimited.

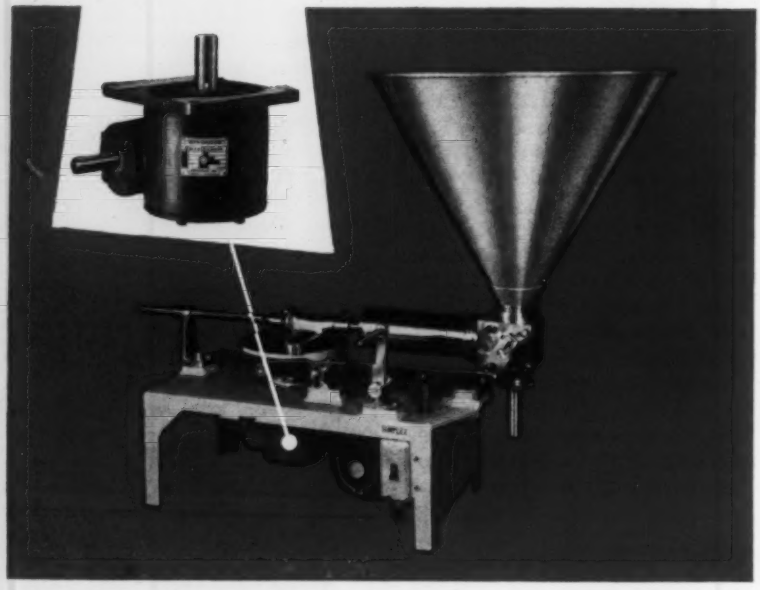
*Teflon is a DuPont trademark for its tetrafluoroethylene resin.

. . . MADE RIGHT IN OUR OWN PLANT

Circle 532 on Page 19

Winsmith speed reducers help simplex piston fillers

pack semi-solids in a hurry!



• *Simplex Table Model "A" Piston Filler, driven by Winsmith "CV" Single Reduction Worm Gear Reducer of 60:1 ratio. Drive motor is ¼ h.p. 1750 rpm, single phase.*

SIMPLEX PISTON FILLERS are "force-feeding" semi-solids into containers at profitable speeds in hundreds of food packing and process plants. Manufactured by F. L. Burt Co., San Francisco, they are cycled to necessary precision by Winsmith Speed Reducers.

WHY WINSMITH? Says President F. L. Burt: *"Winsmith was the first company with a wide range of sizes to fit our needs from stock."* This includes outputs from 1/100 h.p. to 85 h.p. in ratios from 1.1:1 through 50,000:1 in full choice of shaft and mounting arrangements — such a complete selection that you're practically getting "custom" units from standardized stocks! Other big advantages of designing Winsmith Speed Reducers into your product are high output efficiency — maximum torque for the size of the package — dependability established over half a century.

WINSMITH SPEED REDUCERS

WRITE TODAY for Catalogs 155 and SM 57. See the "extras" that are standard in the Winsmith line!

WINSMITH, INC.
16 Elton Street, Springville, (Erie County), N. Y.

throat also serves as a permanent protection for wire insulation at that point. Connector incorporates steel grounding cone and nylon sealing ring. Nylon ring provides mechanical protection for plastic jacket of raceway. Straights, 90 and 45-deg elbow designs are available for conduit sizes from ⅜ through 4 in. **Thomas & Betts Co.**, 36 Butler St., Elizabeth, N. J. D

Circle 699 on Page 19

Toggle Switches

have integral lever lock

TL toggle switches feature an integrally designed lever lock and require a definite pull of approximately 0.090 in. to change lever positions. Lever lock prevents false actuation from objects snagging or hitting toggle lever. Switches have integral terminals,

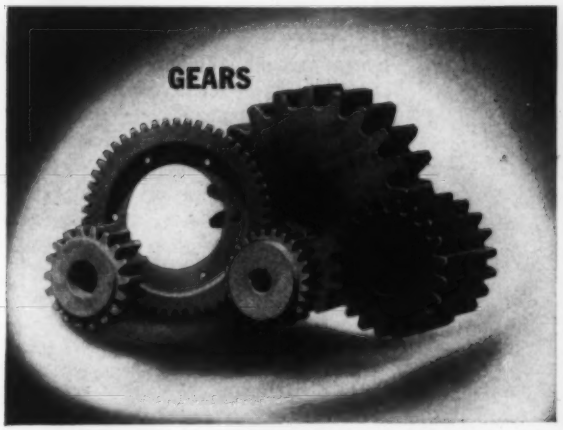
providing easier wiring and stronger connections. Step-design case permits more space between terminals, minimizing possibility of shorting. Designed for use in aircraft, mobile, marine, and electronic applications, switches are available with 11 different toggle-locking positions and three circuitry types. They are rated at 20 amp, 30 v dc, resistive. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

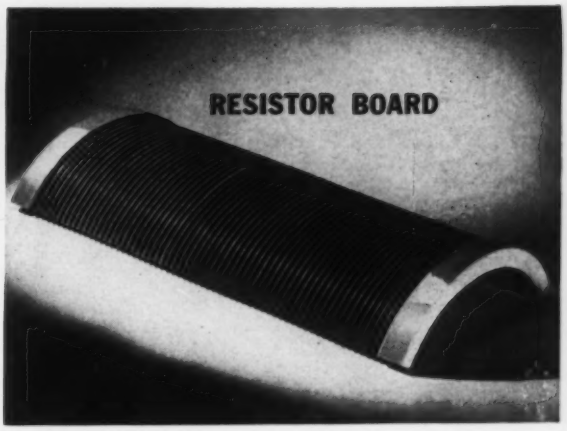
Circle 700 on Page 19

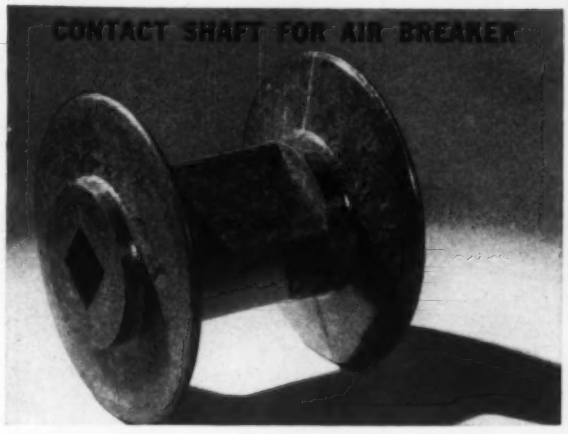
Temperature Control

for use in hazardous locations

D95 explosionproof, remote-bulb temperature control operates over wide ranges in hazardous locations where explosive vapors or gases







Low-cost and with controlled electrical properties. CDF Celoron Molded Plastics are designed for use in electrical and mechanical applications requiring high impact strength with good mechanical and electrical properties.

Close tolerances and high finish with phenolic resin-impregnated CDF CELORON® MOLDED PLASTICS

CDF Celoron Molded Plastics give you all the advantages of low-cost form molding of electrical and mechanical parts. You can even add strength selectively to any section of the item.

Through lower unit costs, CDF Celoron Molded Plastics offer you longer life per dollar invested. Resist water, oil, grease, and many other corrosive solutions and atmospheres. In gears, they operate without continuous lubrication at temperatures of up to 150°F.—300°F. in oil. CDF Celoron Molded Plastics are also sound-absorbent, shock-resistant, and abrasion-resistant.

You can save machining time through CDF's custom molding and complete fabrication facilities. You'll also save costs through CDF's mass production of Celoron parts.

See your CDF sales engineer today. He'll show you how CDF Celoron Molded Plastics, plus complete custom molding and fabrication, can save you production time and costs.

CDF **CONTINENTAL-DIAMOND FIBRE**

A SUBSIDIARY OF THE Bndt COMPANY. NEWARK 23, DEL.

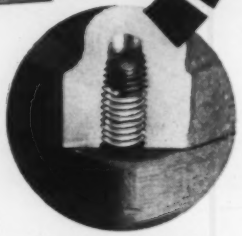
Circle 534 on Page 19

HELI-COIL®

SCREW-LOCK* INSERTS

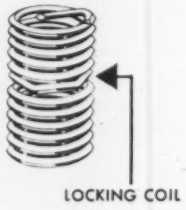
hold fasteners tight!

Designed for greater speed, safety and economy, Chicago Pneumatic Impact Wrenches exert tremendous tightening and loosening power, resist severe shock loads and rough on-the-job use.



Cutaway showing *Heli-Coil* Screw-LOCK Insert in flange seat of Chicago Pneumatic Impact Wrench.

A key feature of their construction is the use of *Heli-Coil* Screw-LOCK Inserts which lock screws within the tapped holes at vital connections. No heavy, protruding lock-nuts are required, no lock-washers. No costly, time consuming lock-wiring. And security? *Heli-Coil* Screw-LOCK Inserts meet Government specs for locking torque and vibration. The wrench is made of aluminum alloy for lightness and ease of handling, but thread stripping in this light metal is eliminated by the stainless steel Screw-LOCK Inserts.



HELI-COIL Screw-LOCK Inserts

- positively lock screws against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling, seizing
- eliminate need for lock-nuts, lock-wiring, other supplementary locking devices
- offer high re-useability on repeated disassembly and reassembly

Screw-LOCK Inserts are available in a complete range of sizes, including the new miniature 4-40. For more information on how to make your product lighter, tighter, more compact or less costly, write

HELI-COIL CORPORATION

Shelter Rock Lane, Danbury, Connecticut

A DIVISION OF TOPP INDUSTRIES, INC.

*Pat. Applied For

HELI-COIL CORPORATION

503 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.

NAME _____ TITLE _____

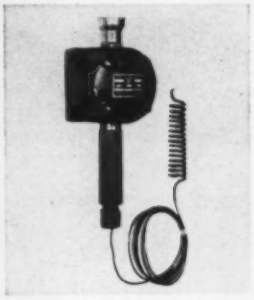
FIRM _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____ 4789

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

are present. Bellows, filled with temperature-sensitive liquid, expands or contracts to operate a snap-acting switch at a preset temperature. Temperature settings are made by rotating a calibrated knob against a graduated barrel. Models are available with adjust-



able range spans of −150 to 650 F with on-off differentials of approximately 1 and 2 F. Switches are available as normally open, normally closed, or double-throw with no neutral position, and are rated for 15 amp at 115 or 230 v ac. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

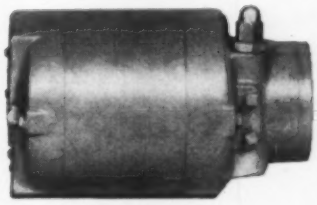
Circle 701 on Page 19

Clutches and Brakes

miniature units have diam of 0.59 in.

Miniature clutches and brakes are intended primarily for airborne or missile-actuator applications where space and weight limitations are primary considerations. They are available in a variety of configurations, consisting of clutches, brakes, clutch-brakes, and dual clutch brakes. Method of mounting is with standard ½-in. servo mount, on either or both ends, with concentric output and input members. Unit shown is Model FB-59 Microbrake. Diameter of all units is 0.59 in. They feature fast re-

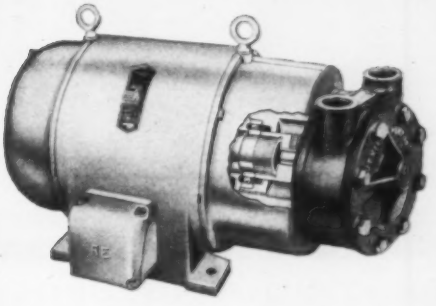
Circle 535 on Page 19



1

2

3 NEW TUTHILL close coupled pump and motor units



3

Save space, Save weight, Cut costs

Now TUTHILL offers three pump and motor combinations developed specifically for applications where space or weight are at a premium. Furnished in a wide variety of sizes and styles, one of these combinations can provide savings in hydraulic, oil burning, lubrication or other services.

The small size of these combinations solves design problems. By reducing weight they cut shipping charges. The elimination of couplings, adapters and bases means lower costs. And even more important savings are often made through the simplification of installation procedures.

Available from Stock

A wide variety of combinations are available immediately from stock, in either large or small quantities.

For example, Number 1 above is TUTHILL'S famous POWERMITE—a combination in which pump and motor are incorporated in one unit which takes up no more space than a standard electric motor (the POWERMITE shown measures only 3⅞" x 7½").

Originally restricted to large quantity applications some POWERMITE models are now available from stock for small quantity orders. The unit shown is rated for 16 GPH at 350 PSI.

For other small quantity applications TUTHILL provides a complete selection of close coupled units with the pump mounted directly on the motor. Numbers 2 and 3 above are typical.

For applications, such as hydraulics which require smaller pumps, units such as Number 2 above provide outstanding advantages. Normally they can reduce space required for pump and motor by at least 6 inches, and cut weight by several pounds. Capacities range from 20 to 300 GPH. Pumps are available for pressures up to 1500 PSI.

Larger pump and motor combinations, such as Number 3 above, can be provided with capacities up to 50 GPM, for pressures up to 400 PSI.

If you are trying to put a pump and motor into a small space, TUTHILL has the answer. Write for details.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Canadian Affiliate:
Ingersoll Machine & Tool Co., Ltd.
Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

☐ Please forward complete information on TUTHILL close-coupled Pump and Motor Units for_____GPH at_____PSI.

☐ Please have your representative call.

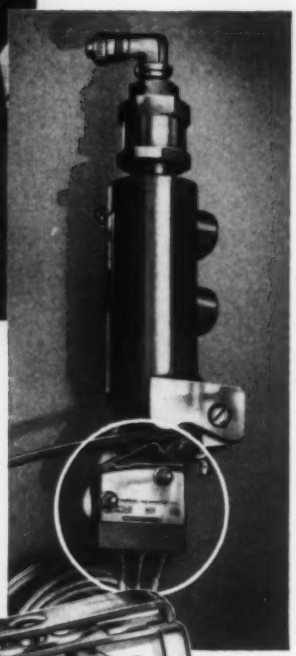
NAME_____TITLE_____

COMPANY_____

STREET_____

CITY_____

STATE_____



KLIXON KX4 Hermetic Switches

help DOUGLAS "Buddy Store" convert any airplane to tanker

Douglas Aircraft's Buddy Store, an in-flight refueling system secured to bomb racks of any airplane, quickly converts it to an aerial tanker. Reliability in the face of sometimes severe environmental conditions is, of course, paramount in the operation of this "tanker kit."

To help insure dependable operation, Douglas selected KLIXON KX4 hermetic switches as integral parts of the Buddy Store electrical system.

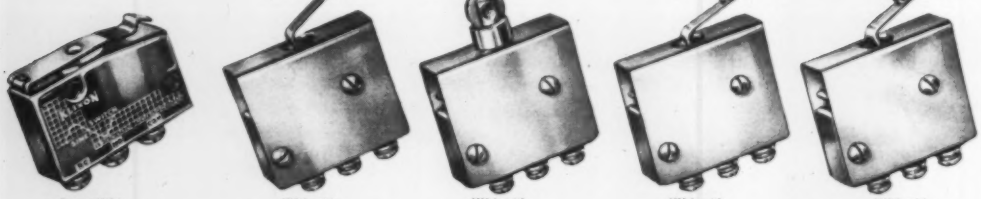
Among the critical functions of the several KLIXON KX4's in the Buddy Store are: indicating to the pilot of the receiving plane that refueling can begin, and controlling retraction of the fuel hose when the operation is completed.

Manufactured to exacting tolerances, the KLIXON KX4 switch has been fully approved under MS 24456 (USAF).

KLIXON KX4 hermetically sealed switches are enclosed in a strong steel case capable of withstanding heavy impact and compression loads. True hermetic sealing is achieved with a metal "wave type" diaphragm at the actuating lever, providing precision switching unaffected by all environmental conditions.

Many types of standard actuation are available, or we'll be pleased to design special packaging to meet the requirements of your application.

Cutaway View



Basic KX4 Sine Switch | KX4 with leaf actuator | KX4 with roller-plunger actuator | KX4 with roller-leaf actuator | KX4 with roller-leaf actuator

Western manufacturers — refer inquiries direct to Metals & Controls Corporation, Southern Calif. Office . . . 232 North Lake Avenue, Pasadena, California. Telephone Ryan 1-4288.

METALS & CONTROLS CORPORATION

Spencer Thermostat Division

3203 Forest Street, Attleboro, Mass.

KLIXON®

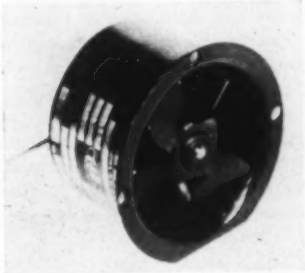
sponse time with low coil wattage. Nonrotating coil eliminates drag and limitations of slip rings. Minimum torque is 4 oz-in., and free drag is less than 0.06 oz-in. Rotor design used permits no radial or axial displacement when engaging or disengaging, and gives zero backlash when engaged. **Magtrol Inc.**, 240 Seneca St., Buffalo 5, N. Y. F

Circle 702 on Page 19

Axial Blower

delivers 10 cfm at 0.11-in. static pressure

New compact, tube axial blower, weighing less than 4 oz, is 1½ in. long, 2 in. in diam, and has 2½ in. mounting flange diam. It is a single-phase unit operating on 27.5 v 400 cycles, and is also available for 115-v 400-cycle. Blower de-



livers 10 cfm at 0.11-in. static pressure with 5 w input. It has stainless-steel bearings and shaft, with anodized-aluminum blade and housing. Unit meets environmental requirements of MIL-E-5272A. **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H. B

Circle 703 on Page 19

Silicone Rubbers

for high-temperature, high-pressure use

Three new silicone rubbers, designated Silastic S-2096U, S-2097U, and S-2098U, are used as oil seals and gasketing materials in automotive, appliance, and aircraft applications where high temperatures and high or constant pressures are present. Containing no toxic additive, they are also satisfactory for O-rings and similar parts in food, drug, and cosmetic processing equipment. Compounds produce 60,

(*Continued on Page 234*)

There's a
GUSHER
COOLANT PUMP
TO FIT EVERY
REQUIREMENT
Inside, outside, flange mounted, immersed type, pipe connected, and tank units . . . you name it . . . we have it. Choose the make and model GUSHER PUMP that best fits your application.
. . . and remember, GUSHER Sealess PUMPS are of advanced design, precision built and electronically balanced. You get long life . . . efficient operation. Write for catalog *today*.
Also available our Rumaco line of self adjusting seal pumps for installations requiring a seal and GUSHER Molten Metal Pumps.
THE Ruthman MACHINERY CO.
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1811 Reading Road
Cincinnati, Ohio

Circle 538 on Page 19

DESIGNING WITH ALUMINUM

NO. 27

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 N. Michigan Ave., Chicago 11, Ill.

THE USE OF ADHESIVES IN FABRICATING ALUMINUM PRODUCTS

LOW COST, VERSATILITY, EASY APPLICATION AND GOOD PHYSICAL AND CHEMICAL PROPERTIES ARE AMONG THE ADVANTAGES OF USING ADHESIVE BONDINGS IN FABRICATING ALUMINUM PRODUCTS.

ALTHOUGH most proprietary adhesives are compounded for specific bonding jobs where certain properties are necessary, they are generally composed of the types listed in Table I. As the table shows, there are many methods of bonding, plus a variety of curing schedules. This versatility of adhesive bonding techniques and joints is the reason for their rapidly expanding use with aluminum. The simplicity of adhesive bonding has also contributed to this success. And the low cost of adhesives has helped them to gain access to jobs formerly held only by solders.

Design Considerations

Design possibilities with adhesively bonded aluminum structures are limited only by extremes of stress, temperature and corrosive environment. Through the use of adhesives, aluminum can be joined to many different materials in one operation.

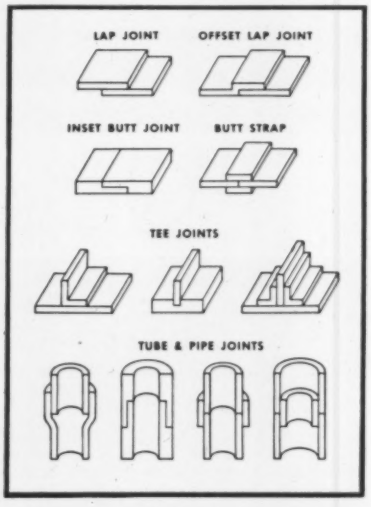
There is only one special consideration in designing for the use of adhesives in joining aluminum; peeling stresses should be kept as low as possible. In some cases it may not be possible to avoid them, but proper joint design will reduce them greatly, thereby assuring a long service life. Figure 1 shows how joints may be designed to minimize peeling stresses which might otherwise exceed the strengths of the adhesives or the materials being joined.

Pretreatments

The pretreatments used in adhesive bonding of aluminum are concerned only with cleaning the surface. In most cases, it is not even necessary to remove the metal's natural protective oxide coating. The cleaning treatment should be selected with joint strength requirements in mind.

For lower strength joints, the ordinary mill finish of aluminum is clean enough. Solvent degreasing to remove thin films of production and handling oils is necessary for intermediate strength joints. Where the adhesive bond must develop the greatest strength possible, a chromic-sulfuric acid dip is

FIG. 1



usually recommended as the best chemical cleaning method. When a variety of materials are to be bonded together, it may be necessary to use several different cleaning methods on the joint areas before bonding.

Methods of Applying

The adhesives themselves may be applied by any of several techniques depending upon the nature of the adhesives and the desired properties of the joint. Roller coating is particularly effective for high speed application of a thin coat of adhesive, as in the production of laminates. Various building materials are currently being adhesively laminated with aluminum foil to increase their thermal insulation properties.

For more limited areas, the adhesives may be applied by brush, blade or spray, which are the more familiar methods. However, certain adhesives are being adapted to mass production practice by their manufacturers who are turning them out in film form. This film is then cut into sheets, ribbons or special shapes which follow the contours of specific joint areas. These precut shapes are then assembled with the metal parts before curing.

Curing

Curing processes for adhesives used in bonding aluminum vary considerably with their type and form. The length of curing time may range from three seconds to 76 hours or more depending upon the type of adhesive and whether or not heat and pressure are applied to the assembled joint. Table I shows the curing times generally used with different types of adhesives. Either heat or pressure, or both, must be used to obtain the highest bond strengths.

Properties of Adhesive Bonds

Although adhesives have been used extensively in bonding aluminum and other metals in jewelry, electronic components and other relatively noncritical items, they can also be used where strengths in the neighborhood of 8,000 psi are required in tension or shear. Table II shows the strengths attainable with various adhesives when used to bond aluminum to aluminum. In general, adhesives are resistant to water and hydrocarbons, an important factor to the manufacturers of containers.

TABLE I

ADHESIVES COMMONLY USED IN BONDING ALUMINUM*

Type	Usual Bonding Methods	Common Curing Time	Resistance to		Performance in Use		Typical Applications
			Water	Hydro-carbons	Structural	Non-Structural	
Polyvinyl Acetates	Solvent Release Water Evaporation Reactivation	At 250°F–350°F, 3 sec	Poor to Fair	Good to Excellent	Poor	Excellent	Aluminum to aluminum, glass, ceramics, mica, wood, cork, leather, cloths, paper and many plastic films.
Cellulose Nitrates	Solvent Release	At room temp. 90 min–24 hr	Excellent	Excellent		Good	Aluminum to aluminum, glass, wood, leather, cloths, thermoplastic resins, etc.
Natural Rubbers	Solvent Release Pressure Vulcanization Water Evaporation	Room temp. 24 hr, 260°F–350°F, 10–30 min	Excellent	Poor	Poor	Excellent	Aluminum to aluminum, tile, glass, wood and metal attachments.
Synthetic Rubbers	Solvent Release Pressure Vulcanization Water Evaporation	Room temp. 24 hr, 260°F–350°F, 5–30 min	Excellent	Poor to Good	Poor	Excellent	Aluminum to rubbers, fabrics, foils, plastics, etc.
Alkyds	Contact Pressure at room temp.	10 min–24 hr	Excellent	Excellent	Fair	Excellent	Aluminum laminations and as sealer.
Epoxys	Catalyst Heat Contact Pressure	12–76 hr 10 min–24 hr	Excellent	Excellent	Excellent	Excellent	Aluminum to aluminum, glass, ceramics, many plastics, cyclized rubbers and wood.
Phenolics	Heat and Pressure	5–10 min	Excellent	Excellent	Good	Excellent	Aluminum to aluminum, wood and glass. Adhesive modifiers.
Phenolic-vinyl	Heat and Pressure	5–45 min	Excellent	Excellent	Excellent	Excellent	Aluminum to aluminum and wood.
Phenolic-polyvinyl butyral	Heat and Pressure	5–45 min	Excellent	Excellent	Good	Excellent	Aluminum to aluminum, wood, synthetic rubber and plastics.
Phenolic-polyvinyl formal	Heat and Pressure	5–45 min	Excellent	Excellent	Excellent	Excellent	Aluminum to aluminum and wood (aircraft construction).
Phenolic-Neoprene	Heat and Pressure	15–30 min	Excellent	Excellent	Excellent	Excellent	Aluminum to aluminum, wood and many plastics.
Phenolic-Buna-N	Heat and Pressure	15–30 min	Excellent	Excellent	Excellent	Excellent	Aluminum to aluminum, brake linings and electrical assemblies.

*Many proprietary adhesives are formulations consisting of a number of basic resin types compounded to achieve specific properties for a specific application.

Some of them offer great resistance to impact in shear, while others maintain their strengths at temperatures higher than 400°F.

Cost Advantages

Today, adhesives range in price from thirty-five cents to five dollars per pound. The lower priced adhesives are the type most generally used in making laminates, the more expensive types for seam bonding. Because adhesives are applied at eight to nine pounds per 1000 square feet, the most expensive adhesive bond costs only one-third the price of an equivalent soldered joint.

For further information and assistance in design or application of adhesives to aluminum, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

TABLE II

STRENGTH RANGE OF ADHESIVE BONDS
Aluminum to Aluminum

Type	Typical Cure Schedule	Approx. Tensile-Shear Al to Al Bonds, psi	Specific Application
Natural and Synthetic Rubbers	Pre dry 1 hr/150°F 5 min/300°F/300 psi	1,150	Aluminum name plates to appliances.
Polyvinyl Acetates	Solvent Release: 230–250°F 5–10 min 350°F ½–2 sec	1,500	Aluminum sheet and foil to masonite. Aluminum foil to paper.
Phenolic Blends	60 min at 350°F and 150 psi	4,200	Aircraft structures.
Epoxys	2 hr at 150°F 10 min at 300°F	6,000 to 8,000	Honeycomb Sandwich and aircraft structures.

see our catalog in PRODUCT DESIGN FILE or write for copy

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

SEE "MAVERICK" • SUNDAY EVENINGS, ABC-TV NETWORK • CONSULT LOCAL TV LISTINGS

NOW...Cold Forged CAP SCREWS with the Setko "Perfect-Hole" Socket!

GRAIN STRUCTURE of steel when cold forged follows a smooth pattern. Compressed Metal has added strength through entire body of screw.

A complete line of Cold Forged Socket Head Cap Screws

produced on specially designed machinery assures perfect, chip-free sockets every time. Hex keys insert completely into the "Perfect-Hole" socket *perfectly*. You get maximum gripping area for equally distributed tightening torque.

Threads are rolled to unmatched precision for snug-hug of mating thread... Available with or without knurled heads in high grade Alloy Steel. Choose from size 8 to ⅜... Isothermal heat treated for extra strength.

Send for the Free Setko Bullseye "Sampler" Puzzle

Get your samples of these top quality Cold Forged Socket Head Cap Screws in this unique and fascinating puzzle... Actually compare these "Perfect-Hole" sockets for yourself. Send today for your free Bullseye "Sampler" Puzzle and for complete information.

SETKO

Set Screw & Mfg. Co.

28 Main Street, Bartlett, Illinois

Circle 540 on Page 19

(*Continued from Page* 231)

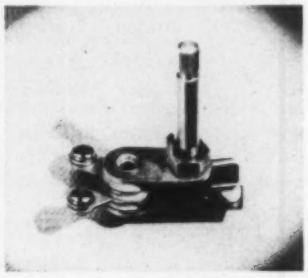
70, and 80 durometer (Shore A hardness scale) respectively, and all three have serviceable temperature range of −70 to 500 F. They exhibit uniform shrinkage during molding and curing, and good resistance to commonly used lubricating oils. **Dow Corning Corp.**, Midland, Mich. H

Circle 704 on Page 19

Adjustable Thermostats

with temperature range of zero to 650 F

Adjustable Type-A thermostats of improved design are for appliances, heating and ventilating equipment, vending machines, and machinery



such as tire molds. They provide an operating temperature range of zero to 650 F and maximum rotation of 300 deg. On noninductive loads, thermostats are rated 15 amp at 28 v dc, 15 amp at 115 v ac, and 10 amp at 230 v ac. Standard mountings include threaded adjusting-stem insert or single-hole mounting No. 8-32 screw. **Norwalk Thermostat Co.**, Norwalk, Ohio. G

Circle 705 on Page 19

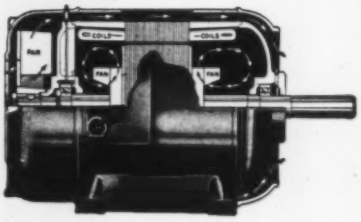
Cylinders

incorporate automatic return controls

Four new lines of automatic-return cylinders and a line of automatically reciprocating air cylinders are available with stainless-steel rods and full choice of mounts and rod clevises. Automatic-return units are available for single control either by electric switch or bleeder valve, and are furnished with rods normally retracted or extended. Single actuation of the control sends rod to full stroke; rod returns automatically upon reaching end of stroke. Electric models are

ELECTRIC POWER AT IT'S MONEY SAVING BEST..!

AIR COOLED

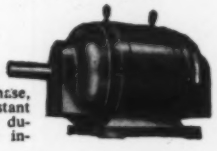


VALLEY BALL BEARING MOTORS

This completely enclosed but... air cooled motor is of the latest design—no foreign matter can penetrate the windings. Its ball bearings and stator core are kept cool by 3 fans which transfer the heat to the frame and end bells — cooling the motor completely — and remember a cool motor runs longer.

Other Types of Valley Motors

Type SN single phase, high torque, constant speed, continuous duty, squirrel cage induction.



Type AN single phase, constant speed, continuous duty, repulsion start, induction run.

Write for Descriptive Literature.

VALLEY ELECTRIC CORPORATION

4221 FOREST PARK BLVD. · ST. LOUIS 8, MO.

Circle 541 on Page 19

PRODUCT-DESIGN MEMOS FROM DUREZ

Selecting a molding compound | **Fire-retardant prepreg** | **Phenolic battery plugs**

How fast is fast?

When you choose a general-purpose phenolic molding compound, how much emphasis should you place on *fast cure?*

If it's speed you want, you can get it—with Durez 265 Black. Cures on the order of 12 seconds have been run consistently.

But let's look at cure speed another way: what happens if a phenolic cures *too* fast? Plunger speed, mold closing time, depth of draw, flow requirements —all impose *minimum* time limits which vary with the job.

Then, too, as the cycle gets shorter, batch-to-batch *consistency* becomes more critical. A 10% variation in cure speed at 12 seconds means only 1.2 seconds leeway between a good piece and a reject.

(We should mention that with Durez 265 you don't have to worry about consistency, even at this fast cure rate. Its uniformity is carefully controlled to insure reproducible results.)

Doesn't it make sense to be sure to choose a molding compound to *do what you want it to do,* rather than solely for the sake of a few seconds' press time?

Many think so. That's why we also stress Durez 791, 792, and 260 Blacks. Why so many? To give you best results under a host of varied conditions: 791 for greatest versatility; 792 for best dimensional stability; and 260 for easiest machinability.

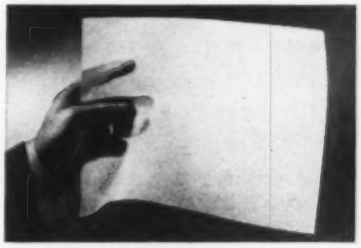
If you'd like to examine for yourself the broad spectrum of properties you can get with these general-purpose compounds, just check the coupon now for data sheets.

Fire-retardant prepreg

Now you can meet the most exacting requirements for reinforced plastic parts that must be strong, tough, and flame-retardant.

You get these properties in a new prepreg, made with Hetron® polyester, that eliminates weighing, mixing, and pouring of resin in your plant.

This material provides exceptionally high tensile, flexural, and impact strengths; smooth glossy surface; and excellent wet-strength retention. It is self-extinguishing without the use of additives.

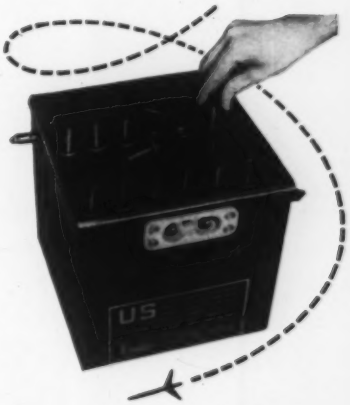


The drapable sheet conforms to complex curvatures, facilitating layup. It is supplied in rolls up to 60 yards long, which have shelf life of six months or more under normal storage conditions.

For a list of manufacturers of prepreg materials, write us. For data on the Hetron resins with which they are made, check the coupon.

Neat stunt

Storage batteries that turn somersaults —and even do barrel rolls—create an



out-of-usual application for phenolics.

These stunting batteries provide ignition and emergency power for military planes. They also pose a design problem: how to vent the cells without losing electrolyte when a pilot puts his plane into a loop.

The answer: a vent with a lead-weighted valve that pops shut as the battery tilts to a predetermined angle, then opens as it returns to level.

Except for the lead weight and one rubber grommet, all parts of the vent plug are made of Durez phenolic. Molded-in threads and valve parts hold close tolerances to prevent leakage and perform within tightly defined limits of tilt, gas pressure, and force of gravity.

This is just one example of the versatility you command when you design with Durez phenolics. Your molder can help you put this versatility to work.

For more information on Durez materials mentioned above, check here:

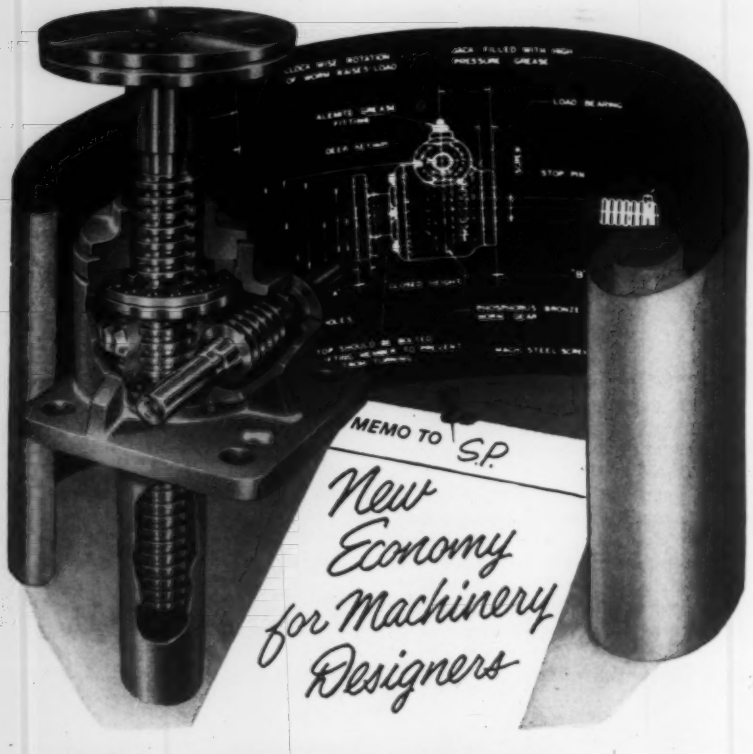
- ☐ General-purpose phenolic molding compounds (data sheets)
- ☐ Hetron polyester resins (technical data file)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
503 Walck Road, North Tonawanda, N. Y.

Circle 542 on Page 19



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

See Worm Gear Jacks At Booth 918, Design Engineering Show

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

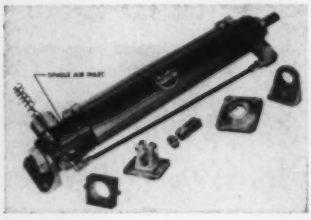
COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

Circle 543 on Page 19



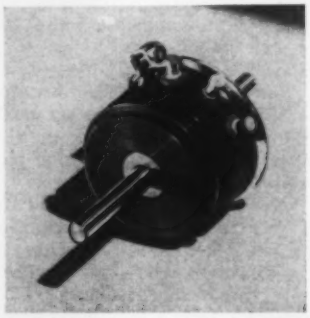
available for 8, 110, or 220-v operation, and all models are furnished in 1½ to 4-in. bore sizes. Automatically reciprocating cylinders require one air connection to cylinder-valve unit and are controlled by a shut-off valve. **A. K. Allen Co. Inc.**, 255 E. Second St., Mineola, N. Y. D

Circle 706 on Page 19

Potentiometers

in eight standard resistance values

High-reliability, precision potentiometers are manufactured with 20-ppm resistance wire and dissipate more than ½ w at 125 C for more than 2000 hr. They are available in eight standard resistance values from 100 to 25,000 ohms. Two basic ⅞-in. diam models have linearities to ± 0.25 per cent for all resistance values, up to nine



taps to ± 0.5 deg, and machined metal housings. **Carter Mfg. Corp.**, 23 Washington St., Hudson, Mass.

Circle 707 on Page 19

Speed Reducer

is motorized, variable-gearhead unit

Motorized Zero-Max stepless variable-speed reducer has torque ratings from 20 to 120 lb-in. by the addition of reduction gearheads of various ratios. Addition of a re-

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

DISASSEMBLED AND AIRBORNE IN 1 HOUR -- that was a basic design requirement for brakemotors powering portable aircraft hoists. Other essentials included extremely light weight, very high power output per unit of volume and very low level of radio interference. S-K custom engineered the design for a manufacturer of special Air Force equipment and has built many units. Power supply for the brakemotors is 28 volts d-c; hoist must be capable of lifting a load of 10,000 pounds; provision is made in the S-K design for regulating the speed of the hoist when load is being lowered.

PURE SINE WAVES FROM 2 to 2000 CPS are needed in the power supply of a massive vibration exciter with continuous rated force output of 12,500 pounds and capable of attaining accelerations up to 10 g with loads of 975 pounds. Precision measurements are based on sinusoidal table motion. Heart of the machine is the S-K rotary power unit comprising: 75 hp 60 cycle motor; 460 v. d-c generator; 230 v. field exciter; 460 v. variable speed d-c motor; and two pure sine wave alternators, one covering the range from 2-500 cps, the other 500-2000. No capacitors are needed for power factor correction over entire range.

IN AND OUT OF COLD STORAGE go the lift trucks that shuttle back and forth in refrigerated warehouses, passing from temperatures of -38° to normal ambients. Starting with its standard design for electric truck motors, S-K developed a special varnish treatment for the Class B insulation to enable it to withstand the severe moisture condensation encountered. This varnish treatment is used on both drive and pump motors, which have been in daily service for periods as long as five years under severe loading conditions; motors have required little or no maintenance.

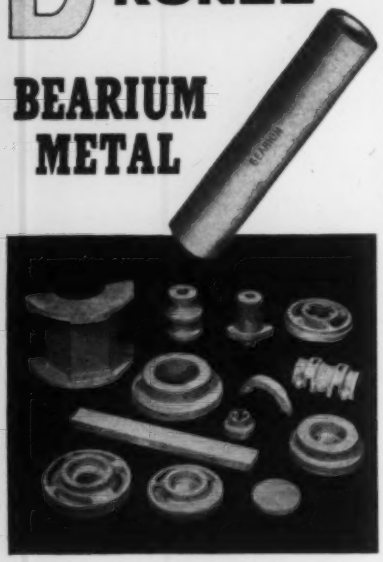
Circle 544 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION
SAFETY INDUSTRIES, INC.
P. O. BOX 904 NEW HAVEN, CONN.

MOTORS • GENERATORS • DISK BRAKES • SPECIAL ROTATING AND CONTROL PACKAGES

Your BEST BUY in BEARING BRONZE

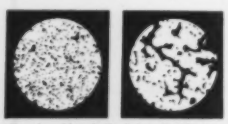
BEARIUM METAL



Words cannot describe the advantages and the superiority which BEARIUM METAL offers over all other types of bearing materials. Only when you use it under the most difficult operating conditions can you appreciate its amazing superiority.

So, if you have a bearing application which involves high speeds, poor lubrication, excessive loads, elevated temperatures, dusty and gritty surroundings—or where a liquid other than oil must be used as a lubricant . . . BEARIUM METAL will prove to be your best investment.

THE SECRET OF BEARIUM METAL'S superiority is due to the uniform distribution of microscopic lead particles within the copper-tin grains rather than between the grain boundaries—as illustrated by these two photomicrographs.



Bearium Metal Ord. Leaded Bronze

FEATURES: Non-Seizing and Non-Scoring • Long-Wearing • Self-Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, uniform structure • Free Cutting.

AVAILABLE IN: cored and solid bars • centerless-ground rods • machined parts • pattern castings.

Tell us your requirements and we'll gladly furnish complete information.

BEARIUM METALS CORP.

192 MILL ST., ROCHESTER 14, N. Y.

West Coast Affiliate:

NEVIN ENGINEERING ASSOCIATES

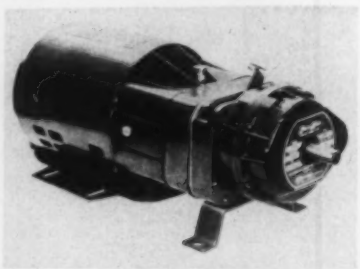
208 Toyopa Drive, Pacific Palisades, Calif.

In Canada:

BEARIUM METALS OF CANADA, LTD.

155 GEORGE ST., TORONTO 2, ONT., CANADA

Circle 545 on Page 19

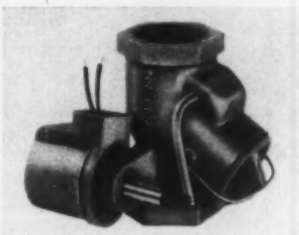


duction gearhead on output shaft boosts torque rating by the amount of reduction-gear ratio and reduces speed range by ratio amount. Stepless variable speed from zero to maximum is still maintained. Unit is available in several combinations of motorized speed reducers and gearhead reduction ratios, providing speed ranges from 0-80 to 0-200 rpm. Standard motor is a 48-frame, 115-v, 60-cycle, one-phase, open dripproof type. **Reeco Inc.**, 1900 Lyndale Ave. S., Minneapolis 5, Minn. J

Circle 708 on Page 19

Drain Valve

for controlled draining or dumping of liquids



Solenoid-operated drain valve, designated No. 8339, originally designed for use in industrial and commercial laundries, can be used wherever controlled draining or dumping of liquids is required. Absence of cavities or obstructions in valve eliminate collection of foreign matter, providing a clean, quick drain. Valve has all-iron construction and stainless-steel seat, including solenoid enclosure. Soft-composition disc and stainless-steel seat provide tight shut-off on 5-ft head pressure. Dumping capacity is up to 118 gpm. Available in 1½ and 2-in. sizes, valve operates on 15 w ac. **Automatic Switch Co.**, Florham Park, N. J. D

Circle 709 on Page 19

Liquid Heating Problems?

Your Chromalox Man has the ANSWERS

Backed by the industry's most complete line of electric heaters, he has heaters specifically designed for oils, water, asphalt, paraffin, salt baths, corrosive solutions and heat transfer media. Standard heaters are ready for immediate shipment from the world's largest stock.

Call your Chromalox Sales-Engineering Representative for clean, safe, economical *Electrical* answers to *all* your heating problems. Or, write to:

2807

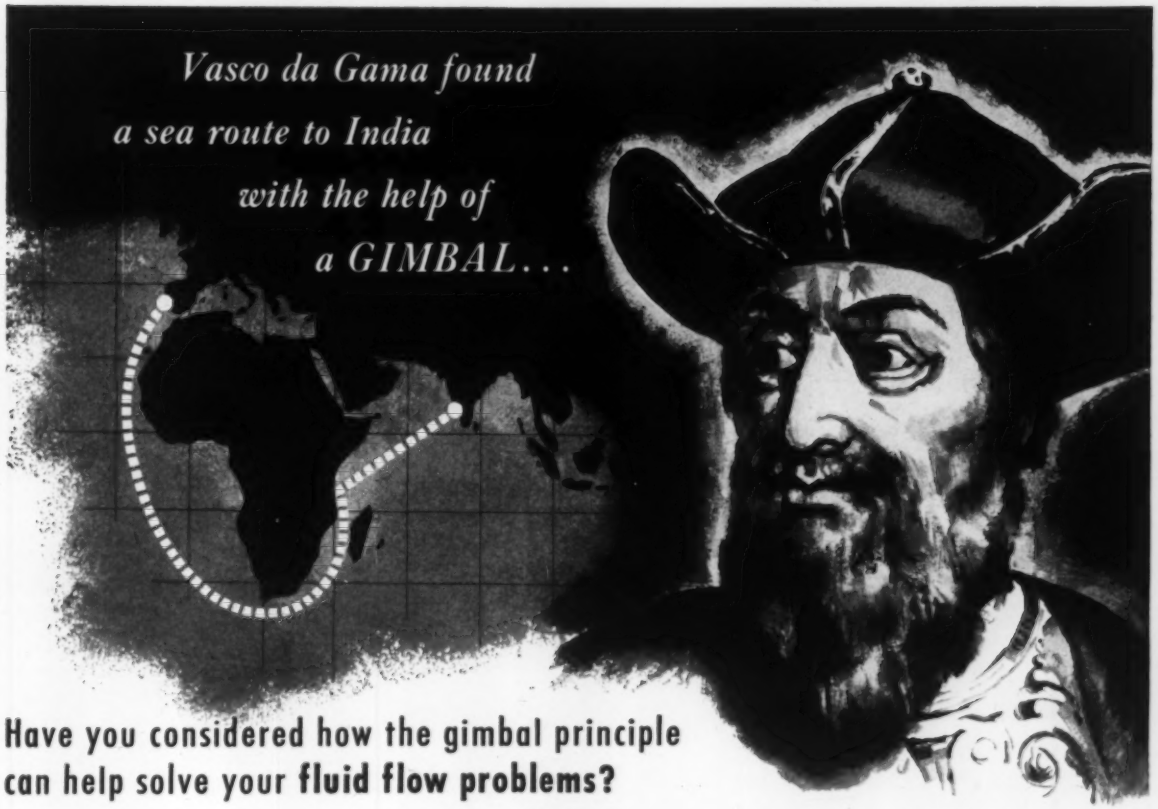
Chromalox Electric Heat

Edwin L. Wiegand Company

7575 Thomas Blvd. • Pittsburgh 8, Pa.

Circle 546 on Page 19

Vasco da Gama found a sea route to India with the help of a GIMBAL...



Have you considered how the gimbal principle can help solve your fluid flow problems?

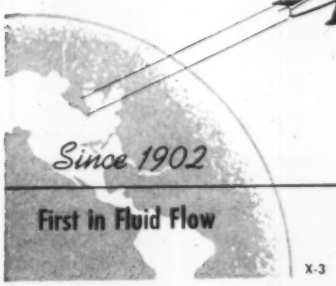
The Flexon Gimbal Joint...

for connections subject to multiplane motions

Vasco da Gama is remembered as the great navigator, a man who sailed off on uncharted seas to find a route to the riches of the East. His principal tool was a compass mounted in a gimbal . . . a device that permitted the compass to incline freely in any direction to compensate for the attitude of the ship.

Four hundred fifty years later Flexonics Corporation borrowed the gimbal principle and put it to work in the piping and ducting of aircraft and missiles. So once again the gimbal is on its way to uncharted reaches.

The Flexon Gimbal Joint is designed to meet problems of thermal expansion, installation misalignment, deflection and high end loading. If you have a connection problem involving radial motion or any of these conditions, we would appreciate the opportunity to discuss the advantages of Flexon Gimbal Joints with you.



X-3

10 plants to serve you in the United States and Canada

Flexonics *Corporation*

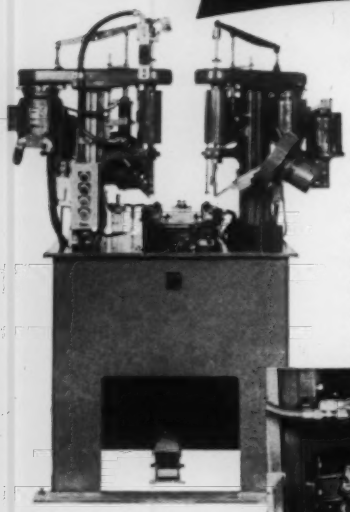
INDUSTRIAL PRODUCTS DEPARTMENT

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

JOB NUMBER SP-9514

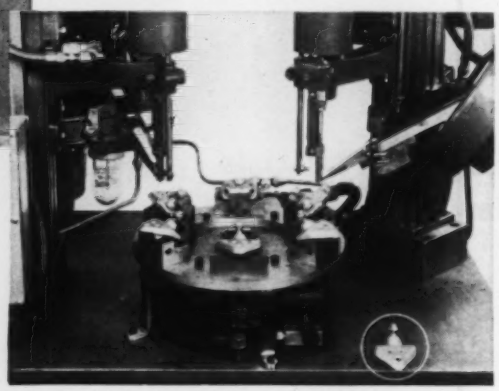
DPS "built-in" mechanical skill



● Pictured is a specially designed machine used for assembling

REAR VIEW MIRROR SWIVEL BRACKETS

The machine consists of two driving heads with automatic feeding devices with an indexing type fixture . . . The operator simply preloads the component parts of the assembly into the dial, and as the dial indexes two screws are driven into the swivel pressure plate at proper tension for adjusting the mirror.



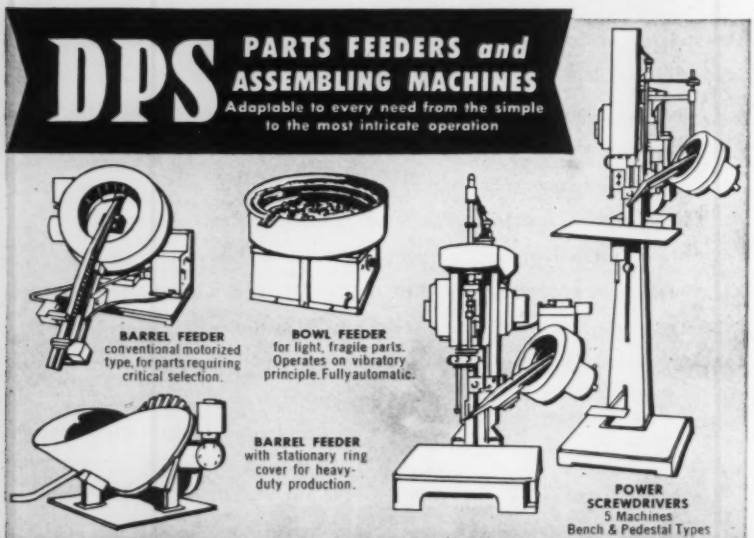
● No mirrors? O.K. No matter what you make, if there's parts to be assembled you'll find the mechanical answer in D.P.S.

POWER SCREWDRIVERS
SELECTIVE PARTS FEEDERS
SPECIAL ASSEMBLING MACHINES

specially adapted to serve your individual feeding and assembling needs at a higher production rate, lower cost, and with greater earnings.

This WAS their problem . . . What's yours?
Give us details . . . Ask for catalog.

DPS PARTS FEEDERS *and* ASSEMBLING MACHINES
Adaptable to every need from the simple to the most intricate operation



BARREL FEEDER conventional motorized type, for parts requiring critical selection.

BOWL FEEDER for light, fragile parts. Operates on vibratory principle. Fully automatic.

BARREL FEEDER with stationary ring cover for heavy-duty production.

POWER SCREWDRIVERS 5 Machines Bench & Pedestal Types

DETROIT POWER SCREWDRIVER CO.
2801-A W. FORT ST. DETROIT 16, MICH.

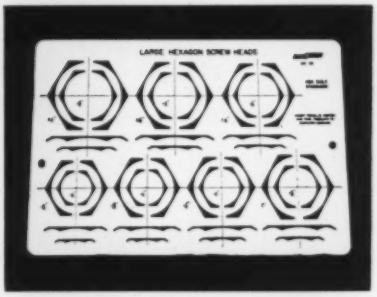
ENGINEERING DEPARTMENT

EQUIPMENT

Template

contains cutouts for large hexagon screw heads

No. 58 template, designed in accordance with ASA B18.2, contains cutouts for large hexagon screw heads from $\frac{7}{8}$ to 2 in., as measured across flat dimensions, and corresponding chamfer circles and symbols for side elevation of crown of hexnut. Template is 0.030 mathematical-quality plastic, and all cutouts are precision



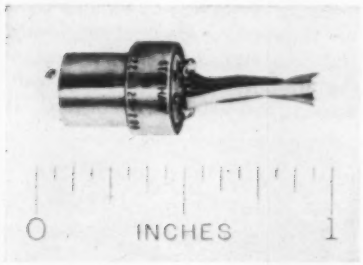
smooth and have pencil allowance. Over-all size is 7 x $10\frac{3}{8}$ in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 710 on Page 19

Pressure Transducer

subminiature unit weighs only 3 grams

Subminiature flush-diaphragm pressure transducer has a diameter of 0.25 in., is 0.47 in. long, and weighs 3 grams. Unit can be adapted to a variety of applications in which the measurement of gage, differential, and absolute pressures is required, such as in airload measurements and wind-tunnel models. Using the principle of the unbonded strain gage, circuit of the instrument forms a complete bridge with nominal resistance of 200 ohms. It has output of about 15 mv full scale open circuit at 3-v excitation. Ambient temperature range is −100 to 275



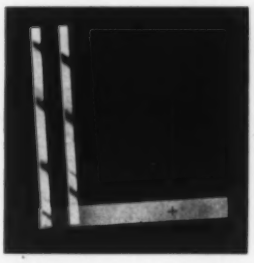
F. Pressure adapters are available to convert unit to closed-line applications. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 711 on Page 19

Ceramic Strain Gages

for laboratory and high-temperature use

Series SC ceramic strain gages are for high-temperature operation, flight instrumentation, and laboratory use. They were designed for easy, rapid determination of the characteristics of dynamic strains in structures, such as the timing of passage of shock waves, vibrational resonant frequencies, and dynamic wave forms of strains produced in structures by nonperiodic forcing functions. Exhibiting extremely high sensitivities, gages are self-generating in nature. They range in size from 3/8 to 1 in. long and 1/16 to 1/4 in. wide. Units will



not materially affect the vibration characteristics of structures. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J. D

Circle 712 on Page 19

Graduated Scale

for precision setting of layout instruments

Micro-Scale provides a simple dimensional standard for precision setting of layout instruments,

QUALITY BALLPOINT PEN DEPENDS ON UNIFORMITY OF 8 GRC "MATED" PARTS

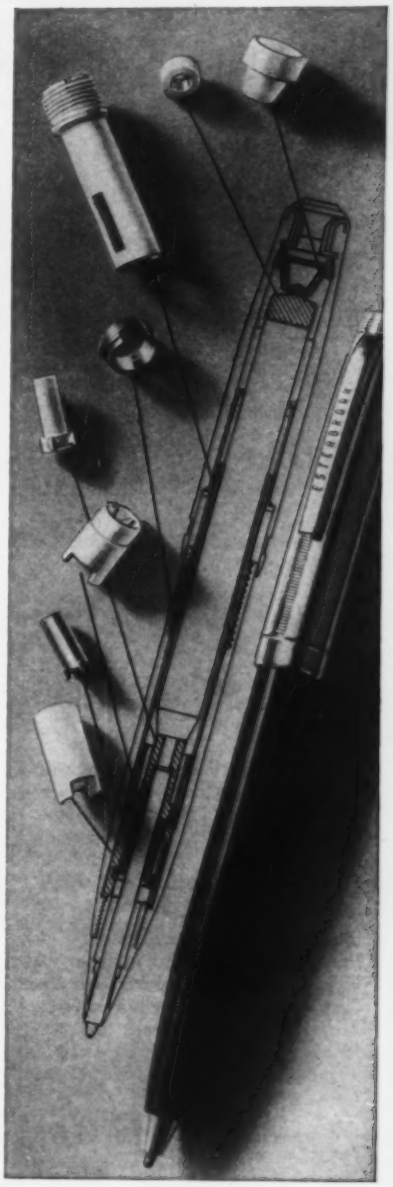
Die Cast and Molded Components Assure Trouble-free Operation of Esterbrook's New Rotating Mechanism

GRC mass-production techniques have again provided a new dimension to designers faced with a difficult situation. Esterbrook engineers, realizing that most people pick up a pen repeatedly the same way, evolved a rotating mechanism to avoid wearing the ballpoint unevenly and to achieve better ink distribution. The intricate mechanism, however, presented a production problem. Parts had to be uniform, durable, meet close tolerances in order to assure proper mating of components and dependable functioning of the assembled pen.

GRC's exclusive patented methods for the precise automatic production of tiny parts solved the problem, and at lower costs. Gries molded five of the parts in duPont nylon, die cast two others in zinc alloy for strength and greatest economy. The eighth was Gries' nylon counterpart for an originally-scheduled screw machine part, produced for a fraction of the cost and more satisfactorily. These eight parts form the foundation of the mechanism for this new-type pen.

Uniformly accurate, clean, well within critical tolerances, these GRC die cast and molded parts eliminated the necessity of selective assembly and insure trouble-free operation by fitting mating parts exactly. Tests of the pen showed parts worked like new after the equivalent of more than a year's normal use, still worked smoothly after the equivalent of fifty years' hard use. (See illustration at left above.)

This high quality pen is typical of the new designs and cost saving economies possible through Gries' unique single cavity molding techniques and ingenious die casting methods. To find out how GRC can help you, write for their bulletins on tiny zinc alloy die castings and molded plastic parts, or send prints for immediate quotations. There is no minimum size. Maximums are 1¾" long, ½ oz. in zinc alloy; 1¼" long, .03 oz. in plastic.



See GRC at the Design Engineering Show BOOTH 850

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES GRC

GRIES REPRODUCER CORP.

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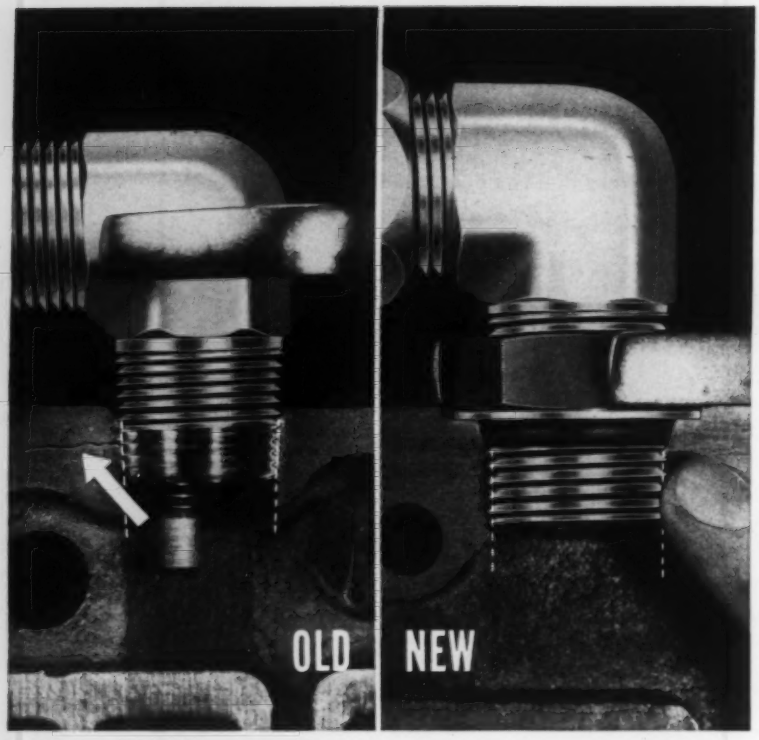
Circle 549 on Page 19

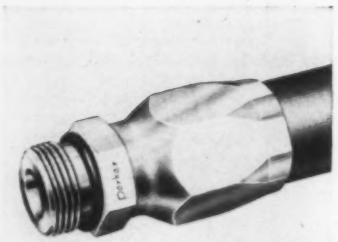


How Parker straight-thread fittings solve leakage problems

Forget about danger of cracking or distorting valve bodies by overtightening the fittings. Forget about messy pipe "dope." Forget about leakage problems resulting from tapered pipe threads in high-pressure hydraulic systems.

Eliminate these problems. Use Parker O-ring seal straight-thread fittings (which conform with the SAE Standard for Hydraulic Tube Fittings) for leakproof, trouble-free connections. Available on both *Triple-lok* (see Catalog 4310) and *Ferulok* (Catalog 4320).

Ask your Parker Distributor today for catalogs or write to —



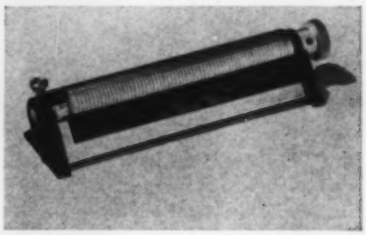
New, Broader Line of *Hoze-lok* fittings for medium- and high-pressure hydraulic service. No skiving of hose cover. Easier make-up saves time and money. Longer performance, greater re-usability. Catalogs 4433 and 4434.

PARKER FITTINGS AND HOSE DIVISION

Section 435-V, Parker-Hannifin Corporation, 17325 Euclid Ave., Cleveland 12, Ohio

Parker Hannifin
creative leader in fluid systems

drafting dividers, and similar tools to three-place decimal accuracy. Unit is equipped with a direct-reading scale and graduated dial, calibrated in 0.001-in. increments. It



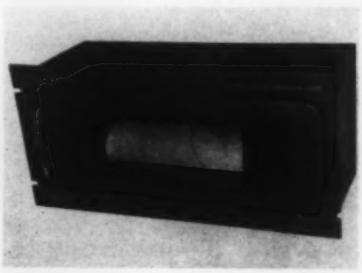
has applications in drafting, tool and die layout, design, inspection, and template work, and is available in lengths of 6, 12, 18, and 24 in. **Trico Machine Products Corp.,** 2664 Grand Ave., Cleveland 4, Ohio. G

Circle 713 on Page 19

Arbitrary Function Generator

generates voltage directly from a graph

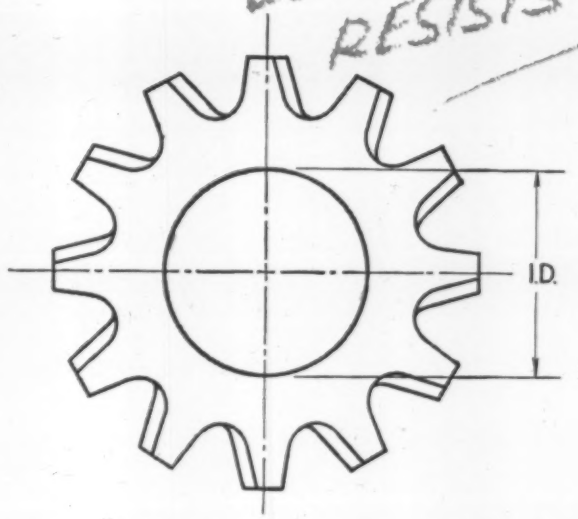
SF-1 arbitrary function generator consists of a chart supporting drum, pick-off resistor, and two contact rollers. Synchronous motor, working through quick-change gear assembly, provides driving force for chart drum. It offers a variety of preselected drum speeds. Any single-valued function, *y*, is drawn with conductive ink, producing a raised surface. Contact is maintained between drawn function, resistance roller, and contact rollers during operation of generator. Electrical continuity between resistance roller and contact rollers is established through the conductive function curve. Voltage developed across output is proportional to ordinate of curve within 0.5 per cent of full scale. Y-axis response time is less than 10 mu sec, zero to full scale. Applications include use in aerodynamic heating simulation,

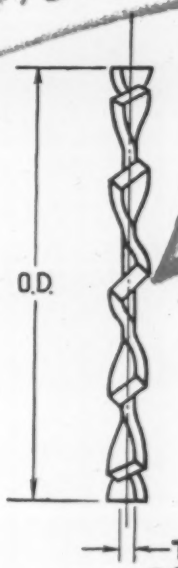


LOCK WASHERS

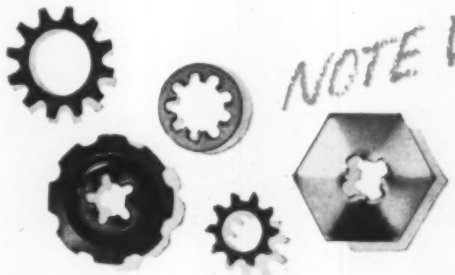
EXTERNAL TYPE

LOCKS TIGHT... RESISTS VIBRATION!





NOTE VARIETY OF STYLES... GET SAMPLES FROM



FUNCTION: Prevent loosening of screws and nuts under vibration. Improve product quality by assuring a tight fastening every time.

DESIGN: Exclusive multiple tooth design provides spring tension, multiple line bite, strut action.

STANDARD VARIATIONS: Ten standard types for external locking and internal locking action, for countersunk screws, elongated holes, high-strength fasteners, etc. Can be pre-assembled to screws or nuts to eliminate time-consuming hand assembly.

TEST RESULTS: Laboratory studies on a recently-developed torque-tension machine show that Shakeproof® Lock Washers have more efficient locking action than any other type washer.

MATERIALS: Spring Steel, Stainless Steels, Bronze, Aluminum, Beryllium Copper, K-Monel.

FINISHES: Plain, Cadmium, Zinc, Parkerized, Chrome, Nickel and others.

SPECIALS: Locking teeth can be incorporated into tab washers, electrical terminals, and special stampings. Sealing compounds available. Catalog lists over 500 standards and specials.

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REMARKS: Approved for military applications and by leading engineering societies.

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In Canada: Shakeproof/Fastex, Division of Canada Illinois Tools, Ltd. Don Mills (Toronto) Ontario

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Floating Labyrinth Seal for temperatures as high as 1400°F. and shaft speeds up to 150,000 rpm.

Metal Bellows Seals to fit any shaft size. Also: Cartridge Seals and Grommet Seals.

CUSTOM-ENGINEERED
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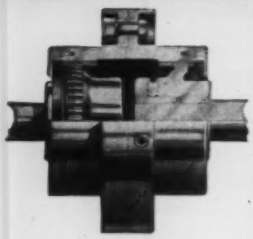
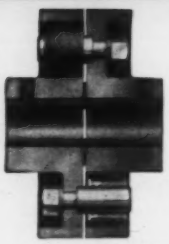
Circle 552 on Page 19

It pays to Specify
AJAX
The World's Most Complete Line of FLEXIBLE COUPLINGS



AJAX DIHEDRAL COUPLINGS

AJAX Patented Dihedral tooth shape handles angular and offset misalignment up to 12 degrees.

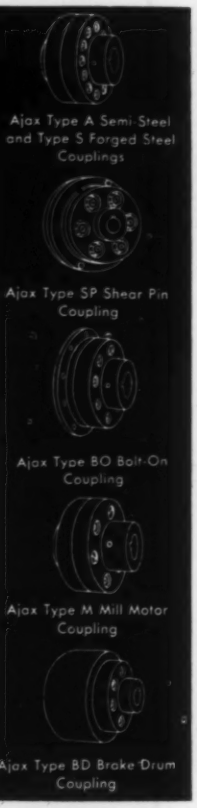


AJAX RUBBER-BRONZE CUSHIONED COUPLINGS

Safeguard your machines against costly shutdowns. Standard of industry for 37 years. All types and sizes.

Write for Ajax Technical Catalogs. Representatives from coast to coast.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK
Also manufacturers of Ajax vibrating conveyors, screens and packers.


Ajax Type A Semi-Steel and Type S Forged Steel Couplings
Ajax Type SP Shear Pin Coupling
Ajax Type BO Bolt-On Coupling
Ajax Type M Mill Motor Coupling
Ajax Type BD Brake Drum Coupling

Circle 553 on Page 19

process control, linear programming of nonlinear functions, and programming environmental test conditions. **Alabama Automation Corp.**, P. O. Box 875, Huntsville, Ala. A

Circle 714 on Page 19

Lead Holder

is lightweight and well balanced

Mark II 5-in. pocket-size lead holder is lightweight and well balanced, with knurled nickel finger grip and

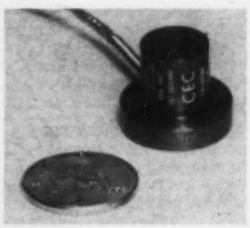
hexagonal tapering. Unit holds 3-mm thick colored refill leads. Jet-black, hard-rubber barrel contains a noncorrosive, propelling coil-spring ejector. Colored top button matches refill leads. **Alvin & Co.**, 853 Palisado Ave., Windsor, Conn. B

Circle 715 on Page 19

Miniature Accelerometer

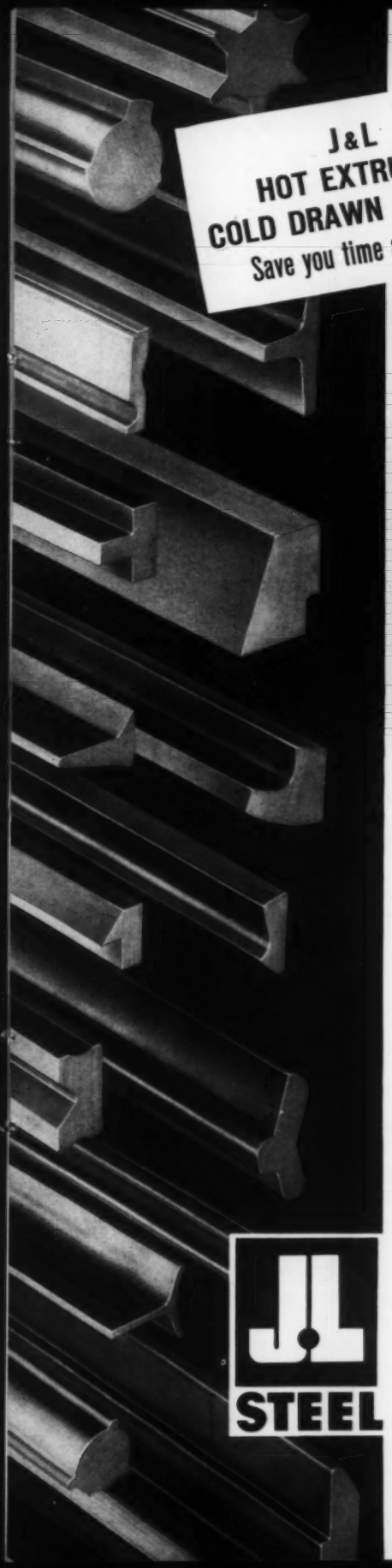
senses vibratory acceleration and shock to 1000 g

Type 4-242 subminiature accelerometer, operating on the electrokinetic principle, senses dynamic accelerations down to 0.01 g from 25 cps to 80 kc. Instrument produces flat response between 50 cps and 60 kc. It senses vibratory acceleration and shock up to 1000 g, with reading not affected by 200-g steady-state acceleration. Unit operates at temperatures from



−10 to 140 F. Accelerometer is particularly suitable for testing small, lightweight components. **Transducer Div., Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif. L

Circle 716 on Page 19



J&L
HOT EXTRUDED
COLD DRAWN SECTIONS
Save you time and money

Hot Extruded, Cold Drawn Steel Shape

"CUTS COST OF CONTROL PART 50%"

... reports Goss Company

A saving of 50% was accomplished by using a 70-inch long hot extruded, cold drawn shape in this ink control part for a printing press. The section is made of AISI 1018 steel, stress-relieved and cut to length, ready for installation after drilling. The Goss Company formerly machined this part from hot rolled flats in nine operations.

By following hot extrusion with cold drawing, Jones & Laughlin economically produces steel sections of complicated design with extremely close tolerances. Mechanical properties are uniform throughout the bar.

These unique sections can save you time and money by reducing machining operations. Scrap losses are small. Quantities are flexible and the range of sections that can be produced is almost unlimited.

Let us show you how you can directly benefit from this cost cutting process. Call your J&L district office or write direct to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Penna.

J&L STEEL

Jones & Laughlin Steel Corporation

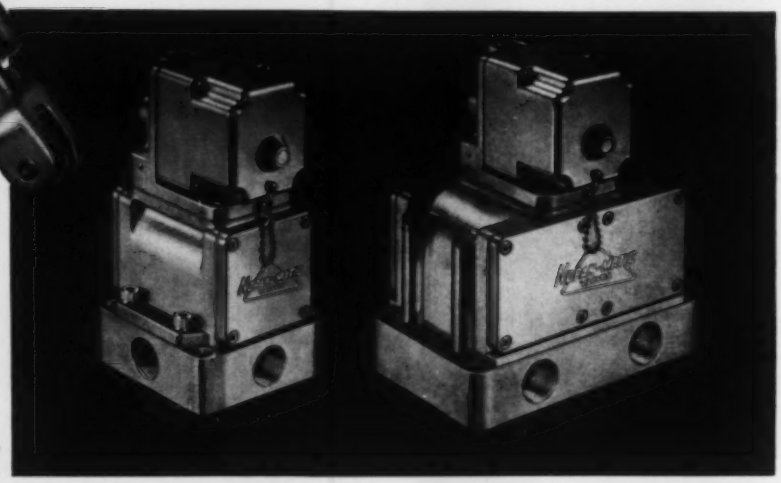
PITTSBURGH, PENNSYLVANIA

Circle 554 on Page 19

New NOPAK *Team*

delivers PLUS VALUES in Air Power!

NOPAK Air Cylinders, long known for their dependability and economy, now can be applied to even greater advantage with the new Nopak-matic pilot operated air control valves. Full flow design and dependable performance make NOPAK Cylinders and Nopak-matic control valves the perfect "team" for "in plant" or O.E.M. applications. They deliver Plus Values that you can measure in terms of greater speed, higher efficiency, easier maintenance, a wider range of adaptability and versatility.

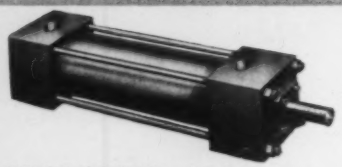


• NOPAK Class 1 and 2 Cylinders are available in 7 standard mountings in bore sizes from 1½" to 14" with a choice of non-cushioned, self-regulating or adjustable cushioned heads on all models.

• Nopak-matic, Pilot-operated, Poppet-type Air Control Valves are available in ¼", ⅜", ½" and ¾" pipe sizes for 2- or 3-Way normally open or normally closed operation, and 4-Way operation with master (air), single or double solenoid control heads. All 4-Way valves available, as standard, with choice of side or bottom ported sub-plates. Air pressures to 150 p.s.i.

Catalog 101-A and Catalog 105 provide complete descriptive and engineering data.

Other NOPAK Products for your Fluid Power Needs



• **CLASS 3 CYLINDERS**—for pressures to 2000 p.s.i. Compact steel plate square head and tie-rod construction. Honed steel tubing. Heads may be cushioned or non-cushioned. Available in 14 standard mounting styles.

• **CLASS 4 CYLINDERS** — High Pressure Hydraulic — Heavy, honed steel tubing with lock-ring flange construction. For hydraulic (oil) service at line pressures to 3000 p.s.i. Choice of cushioned or non-cushioned heads. Available in 5 standard mounting styles.

• **CLASS M CYLINDERS** (Mill Type) Welded flange construction, with honed steel tubing, eliminates tie-rods. Recommended for all types of Heavy Duty air or hydraulic pressures up to 650 p.s.i. depending upon diameter.

The NOPAK line includes cylinders and valves for a wide range of fluid power application — and its precision control. In addition to standard air cylinders, there are heavy duty, mill-type cylinders, square head and lock-ring flange type hydraulic cylinders. The NOPAK Valve line includes the famous packless rotating disc valves in both hand and foot models, high pressure hydraulic valves, Flotrol speed control valves and reciprocating valves.

NOPAK 2- 3- AND 4-WAY HAND VALVES are used to control single or double-acting cylinders at air or hydraulic line pressures to 250 p.s.i. Precision lapped seal eliminates packing, prolongs valve life. Disc rotating at right angle to stream flow permits throttling action or immediate opening to full pipe area. Pipe sizes from ¼" to 2".

NOPAK 2- 3- AND 4-WAY FOOT VALVES incorporate all of the features of NOPAK hand operated disc-type valves including the lapped-disc design and packless construction. They are available in 3 types which are adaptable to a wide variety of control needs. Pipe sizes from ¼" to 1" for pressures to 125 p.s.i.

NOPAK FLOTROL SPEED CONTROL VALVES provide uniform control of cylinder speed in one direction, free flow in the other. Features: quick, easy, precision adjustment without tools; greater capacity; easy installation because of compact in-line design; fit in tight places; made of rust and corrosion proof materials. Pipe sizes from ¼" to 1".

Write for Catalog SW-3

NOPAK *VALVES and CYLINDERS*

GALLAND-HENNING NOPAK DIVISION • 2752 South 31st St. • Milwaukee 46, Wis.

A7-618-1P

Circle 555 on Page 19

THE ENGINEER'S

Library

Recent Books

Polyurethanes. *By Bernard A. Dombrow, Nopco Chemical Co., North Arlington, N. J.; 176 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.50 per copy.*

Applications of polyurethane rubbers, adhesives, coatings, and flexible and rigid foams are discussed in this book. General principles are emphasized and chemical reactions of urethane formulations are kept to a minimum.

Physical properties of the urethanes are discussed according to application requirements. Also included are considerations and advantages of using urethane foams for electronic component packaging and potting, and safety aspects of handling diisocyanates.

Plastic Sheet Forming. *By Robert L. Butzko, Auto-Vac Co., Bridgeport, Conn.; 181 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.50 per copy.*

This book surveys a number of applications which pertain to specific properties of plastic sheet. Fourteen different kinds of products and the sheet-forming technique associated with each are discussed.

Included are material selection for specific applications, equipment molds and mold designs, and comparative costs of materials and processes. An introduction to sheet forming and variations in methods are provided for designers and technicians.

Engineering and Technical Conventions, 1958. *24 pages, 8½ by 11 in., paperbound; published by and available from Industrial Relations News Inc., 230 West 41st St., New York 36, N. Y.; $3.00 per year including a September supplement.*

(*Please turn to Page 250*)

FOR INSTANT STARTING, SMOOTH STEPLESS SPEED CONTROL

MAGNE-SPEED
NON-ELECTRONIC
VARIABLE SPEED DRIVES

Featuring simple circuitry, MAGNE-SPEED drives provide high efficiency operation at competitive cost. Non-electronic, they require no warm-up time. Excellent regulation without tachometer.

MAGNE-SPEED JUNIOR

MAGNE-SPEED SIZE I

REGULATION: *Approximately ±4% of base speed*
RANGE OF ADJUSTMENT: *Zero to Full speed*
WIDE SPEED RANGE: *Base speed 2000 r.p.m. to approximately 40 r.p.m. . . . a 50:1 range. (4000 r.p.m. available on special order).*
COMPACT . . . SIMPLE INSTALLATION

STANDARD SIZES AVAILABLE

TYPE	HORSEPOWER RATING	SPEED RANGE	BULLETIN #
JUNIOR	1/100 to ⅛ HP	40:1	S-790
SIZE I	¼, ⅓ and ½ HP	50:1	S-580
SIZE II	¾, 1 and 1½ HP	50:1	S-580

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Circle 556 on Page 19

(Advertisement)

THE DODGE STEEL ladle

BUSINESS MAGAZINE EDITION

PUBLISHED BY **DODGE STEEL COMPANY**
6501 Tacony Street, Philadelphia 35, Pa.

This is important enough to read twice!

If your activities involve product design and development, purchasing, production . . . or management, you should know about the complete manufacturing service offered by Dodge Products.

This unique division of Dodge Steel Company was originally established for the purpose of machining quality steel castings as an additional service to its customers. However, diversification has multiplied its products and services until today, there is hardly an industry that is not benefiting in some degree, from the research, development and experience of this manufacturing organization.

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Dodge Products offers you a complete manufacturing service in the literal sense of the word . . . *from idea to finished product*. This service extends from product design engineering and development—through the machining and fabricating of just about any metal or material—to the production of finished parts, components or products.

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The services offered by Dodge Products are streamlined to save time, trouble and money for you. When parts or components are fabricated by us, you relieve yourself of production and labor problems. Mistakes, rejects, machinery breakdowns are *our* headaches. The scrap problem is *ours*. You have only to receive and give final inspection to the finished parts. These are delivered *on time*, ready for your production line.

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- Turning in all metals
- Boring—horizontal and vertical
- Welding—all types
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- Production tapping
- Bending
- Shaping
- Long or short production runs
- Casting and patternmaking
- Hydrostatic testing
- Magnaflux and X-ray testing
- Drafting
- Strain Laboratory

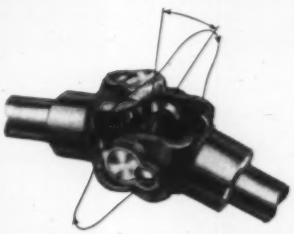
Like to know more about this unique custom manufacturing service? This new bulletin describes in detail the many services we offer. Write for a free copy today.

you'll want this idea starter...

If you are looking for new ways and means to improve your product, and save money too, here's an idea source guaranteed to spark your imagination and give you a wealth of hints, tips, and suggestions.

The Dodge Steel Ladle is an 8-page, quarterly magazine. It contains how-to-do-it articles on steel castings . . . "case history" examples of how castings are used in industry . . . informative discussions on how castings are made . . . news about developments in Dodge Products. And, that's not all! There's a lot more information as well . . . data that you'll find of constant value and interest. Like to be put on the mailing list? Just tell us and we'll do the rest. No obligation, of course.

Only Rzeppa gives you both!



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. To eliminate "rock and roll" action, they must use precision alignment techniques to provide for either higher angles or smooth rotation. But Rzeppa gives you *both* to begin with!

You don't have to sacrifice high universal joint working angles to get smooth rotation—because Rzeppa Joints give you both!

Every Rzeppa (pronounced "Sheppa") Universal Joint has constant Velocity action—100% smooth torque—for longer joint and bearing life. Single Rzeppa Universal Joints give up to 35° working angles, or as high as 70° when coupled for double-action flexibility.

In every application—aircraft, vehicular, industrial—Rzeppa Joints offer more money-saving advantages wherever universal joints are used.

SEND FOR LATEST BROCHURE

—or send us a dimensional sketch along with peak horsepower, R.P.M., and operating angles. Our engineers will assist in making a proper joint selection.

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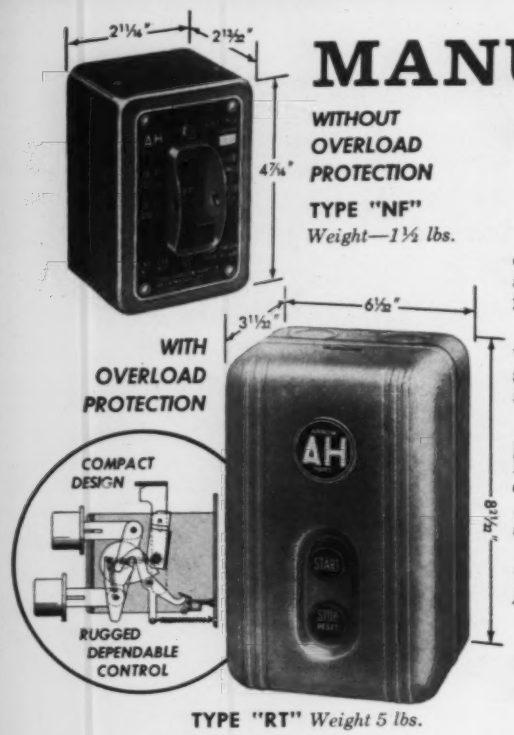
RZEPPA "SHEPPA"

Constant Velocity Universal Joints

58RJ-2

THE GEAR GRINDING MACHINE CO., 3937 CHRISTOPHER, DETROIT 11, MICHIGAN. MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES. DETROIT 750 SINGLE SPINDLE SCREW MACHINES.

Circle 558 on Page 19



TYPE "RT" *Weight 5 lbs.*

MANUAL STARTERS

COMPACT... ECONOMICAL COMPLETE LINE

Type "NF" Manual Starters . . . toggle-operated, without overload protection . . . are *compact*, and completely dependable. Rated to 30 Amp., 2 hp capacity at 600 volts. Available in 2, 3 or 4 poles.

Type "RT" Manual Starters . . . push button operated, with overload protection . . . are *small* and reliable. Control single and polyphase motors up to 7½ hp, 600 volts. Available in sizes 0 and 1.

Both "NF" and "RT" types supplied with general purpose, weatherproof or explosion-proof enclosures. Arrow-Hart's complete line also includes manual starters, without overload protection, for reversing and two-speed applications . . . and toggle action switches for other manual starter applications.

Write on company letterhead for 12-page catalog section to The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

ARROW – HART OF HARTFORD

Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 559 on Page 19

ARROW AH HART

ENGINEER'S LIBRARY

(*Continued from Page* 247)

This 6th annual edition includes national, state, and regional meetings and conventions of major societies and organizations in technical fields from February 1 through December 31, 1958.

It gives date and place of meeting, sponsoring organizations, title of meeting, and estimated attendance. It also offers an alphabetical index of technical societies and organizations, addresses, and names of officers to contact for meeting information.

A supplement is published each fall covering meetings from September through January for which information was not available in time for the annual issue.

Motivating Factors in Engineer Employment, Parts 1, 2, and 3. *Each part is 8½ by 11 in., stapled, and paperbound; published by and available from Industrial Relations News, 230 West 41st St., New York 16, N. Y.; $2.75 per copy or $7.50 for three parts.*

Part 1: A Conceptual Scheme of the Employment Process; 13 *pages.* This report offers a systematic approach to the understanding of engineer motivation and behavior in the recruitment process.

Part 2: The Motivating Factors in Engineer Employment; 15 *pages.* Motivation factors which play a predominant role in engineer job selection are discussed in this report. Included in chart form and in order of appeal are key factors which influence engineers in selecting a job.

Part 3: The Motivating Factors in Engineer Employment; 24 *pages.* Covered in this report are childhood personality traits, hobbies and cultural interests, and other factors which motivate engineers in selecting specific fields of employment.

Polyamide Resins. *By Donald E. Floyd, General Mills Inc., Minneapolis, Minn.; 230 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.50 per copy.*

This book covers the formulation and raw materials of polyamide resins, methods of resin manufacture, and a discussion of key properties on which applications are based.

Included are chapters on fibers and filaments, coatings and films, moldings, extrusions, adhesives, castings, and sealants. Applications are related to resin structure and are classified according to property considerations. Future trends in polyamide application are predicted and discussed.

Analytical Kinematics of Plane Motion Mechanisms. *By Jesse Huckert; 209 pages, 7½ by 10 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$7.75 postpaid.*

This book defines concepts of motion and establishes motion relationships, both by means of vectors. Contents include elements of vector analysis, velocities in mechanisms, cams and cam mechanisms, profile contact mechanisms, and

nature of toothed gearing.

Association Publications

Steel Pipe Flanges and Flanged Fittings. *76 pages, 8½ by 11 in., paperbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $3.00 per copy.*

This new American Standard, ASA B16.5—1957, includes applicable requirements relative to flanged end and butt-welding end valves. Also included are materials selection guides, pressure and temperature ratings, methods of designating locations of tapped drain holes and outlets, relationship of end flange-facings to flange thickness, and tables of dimensions for fittings.

Fundamentals of Steel Castings Design. *By Charles W. Briggs; 34 pages, 6 by 9 in., paperbound; available on letterhead request from Steel Founders' Society of America, 606 Terminal Tower, Cleveland 13, Ohio*

This book discusses the why and how of steel casting design. Included are basic rules of design, strengths of cast steel, safety factors, minimum section thickness, section design advantages, recommended practices for section changes, design of joined sections, exterior corners, reinforcing members and cored openings, dimensional tolerances, redesign of castings, forgings redesigned as castings, and redesigned weldments.

American Drafting Standards Manual, Sections 3 and 6. *Each section is 8½ by 11 in., paperbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per section.*

Section 3, ASA Y14.3—1957—Projections; 11 *pages.* Contents of this section cover third-angle orthographic projection, choice of views, partial and special views, and intersections. Also included are auxiliary and double auxiliary views.

Section 6, ASA Y14.6—1957—Screw Threads; 18 *pages.* This section covers disposition of tolerances, allowances, and crest clearances for Unified and American Thread Classes 1A, 2A, 1B, and 2B. Also included are thread representation and dimensioning.

1957 Supplement to Book of ASTM Standards Including Tentatives, Parts 1, 2, and 6. *Each book is 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.00 per copy.*

Part 1—Ferrous Metals; 520 *pages.* This book includes 80 standards covering steel pipe (welded and seamless, high-temperature service, stainless, etc.), steel tubes, steel castings, bolting materials, boiler and pressure-vessel plate, structural and rivet steel, sheet and strip, forgings, concrete reinforcement, metallic-coated steel products, cast iron, spring steel, steel chain, and ferro-alloys.

Part 2—Nonferrous Metals; 380 *pages.* Included are 56 standards covering copper and copper-base alloys, aluminum and aluminum-base alloys, magnesium and magnesium-base alloys, electrical heating, resistance and related alloys for radio tubes, electrodeposited

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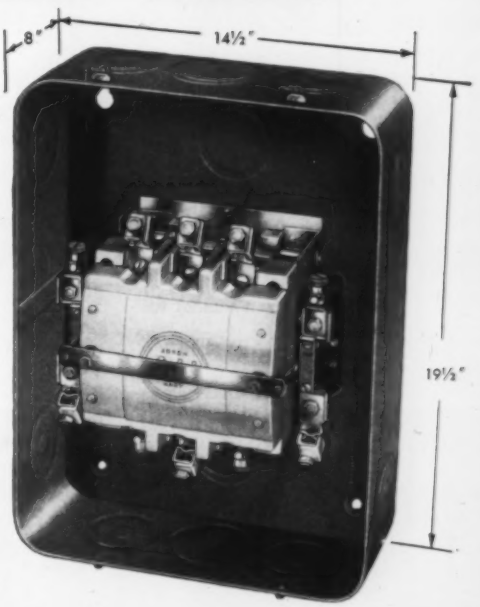

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Circle 561 on Page 19

metallic coatings, die-cast metals, and corrosion tests and general methods of testing.

Part 6—Rubber, Plastics, Electrical Insulation; 423 *pages.* Included are 70 standards covering rubber products, automotive and aeronautical rubber, packing and gasket materials, hose, insulated wire and cable, carbon black, electronics materials, and plastics.

Letter Symbols for Heat and Thermodynamics. 14 *pages,* 8½ *by* 11 *in., paperbound; published by and available from American Society of Mechanical Engineers,* 29 *West* 39*th St., New York* 18, *N. Y.; $1.50 per copy.*

American Standard ASA Y10.4—1957 covers general and special principles of letter symbol standardization, symbols for primary concepts, lists of ASA publications in which symbols appear, and alphabetical listing of symbols by concepts.

Government Publications

NACA Technical Series. *Each publication is* 8 *by* 10½ *in., paperbound; copies available from National Advisory Committee for Aeronautics,* 1512 *H St., N. W., Washington* 25, *D. C.*

The following Technical Notes are available:

TN 4036. Creep of Aluminum-Copper Alloys During Age Hardening. 73 *pages.*

TN 4101. Effect of Lubricant Viscosity on Rolling - Contact Fatigue Life. By T. L. Carter, Lewis Flight Propulsion Laboratory; 25 *pages.*

TN 4104. Effect of Lubricant Viscosity on Rolling - Contact Fatigue Life. 25 *pages.*

TN 4138. Creep Deformation Patterns of Joints Under Bearing and Tensile Loads. 36 *pages.*

TN 4141. The Useful Heat Capacity of Several Materials for Ballistic Nose-Cone Construction. By J. A. Stalder, Ames Aeronautical Laboratory; 19 *pages.*

TN 4161. Effect of Lubricant

(*Please turn to Page* 255)

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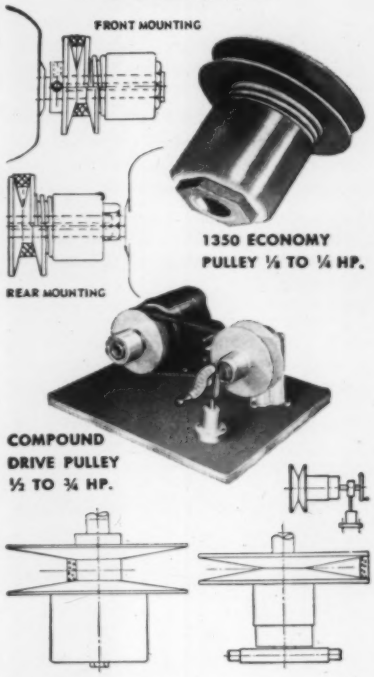

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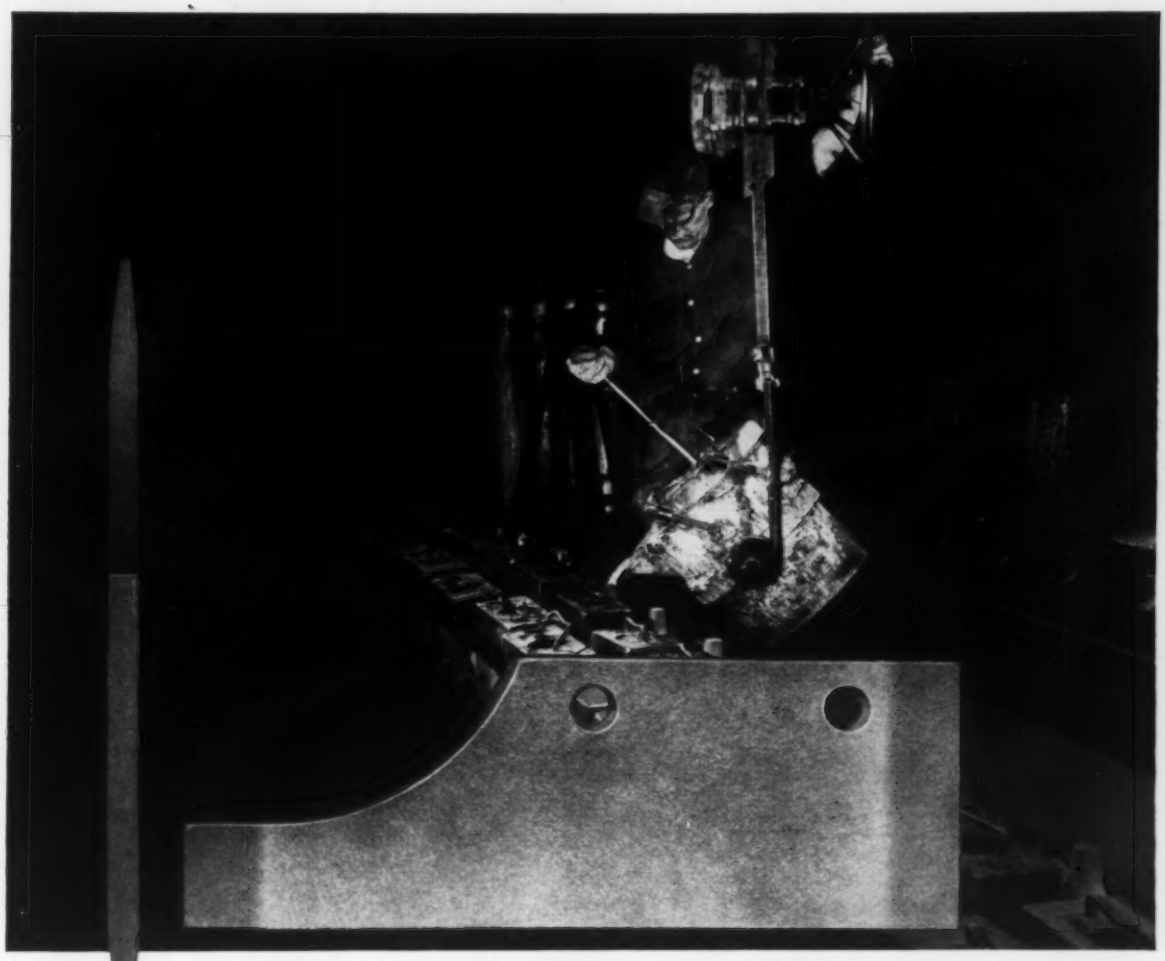
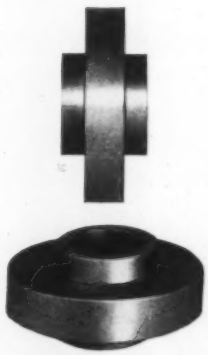


This customer SAVED TWICE with Ampco Shell Moldings



Gear blank shell-cast in Ampcoloy nickel bronze. Surface finish was held to ± .015. Only finishing required was to hob teeth and broach key-way. Savings were considerable.

In the wear strip above, shell-cast of Ampco Metal, all dimensions including end-bevels and hole locations were held to ±.015. The smooth surface finish required no machining. Substantial savings of time and money were realized.

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Ampco Shell Moldings are available in an extremely wide range of copper-base alloys. Ask an Ampco field engineer to tell you more about this money-saving production process. And write for Bulletin G36-957. *Ampco Metal, Inc., Dept. MD-3, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, Calif.—Southwest: Dallas (Garland), Texas)*

RM-9

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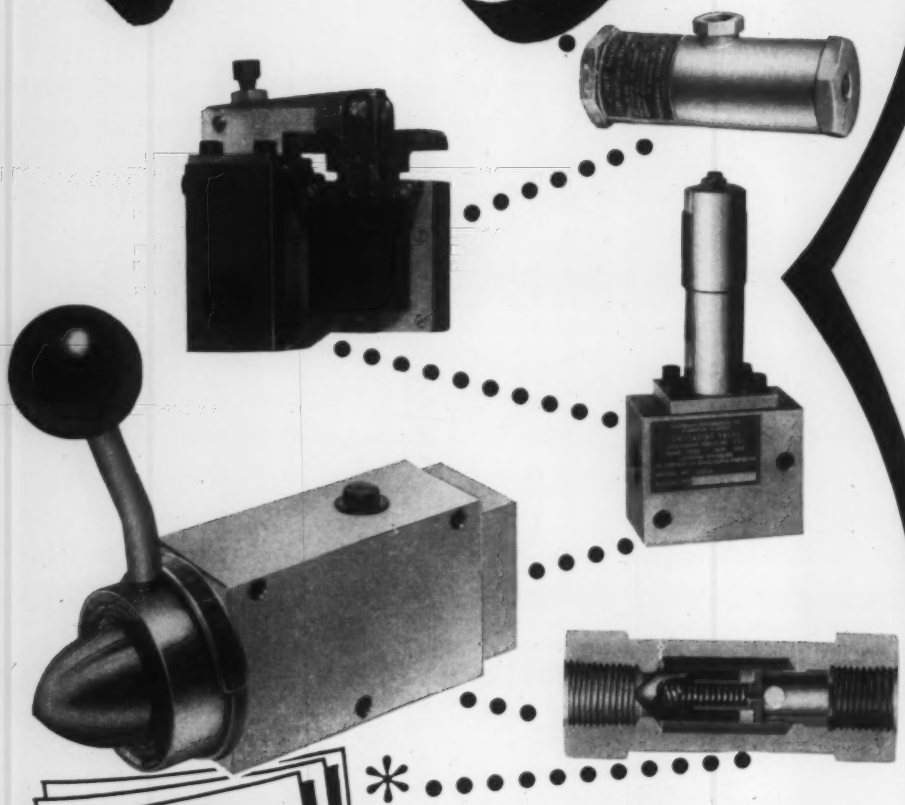

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(*Continued from Page 252*)

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OTS Research Reports. *Each publication is 8 by 10½ in., paperbound, and side-stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following research reports are available:

PB 121161. Thin Films of Polytetrafluoroethylene Resin (Teflon) as Lubricants and Preservative Coatings for Metals. 30 *pages;* $1.00 *per copy.*

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Takes 35 "Bites" *

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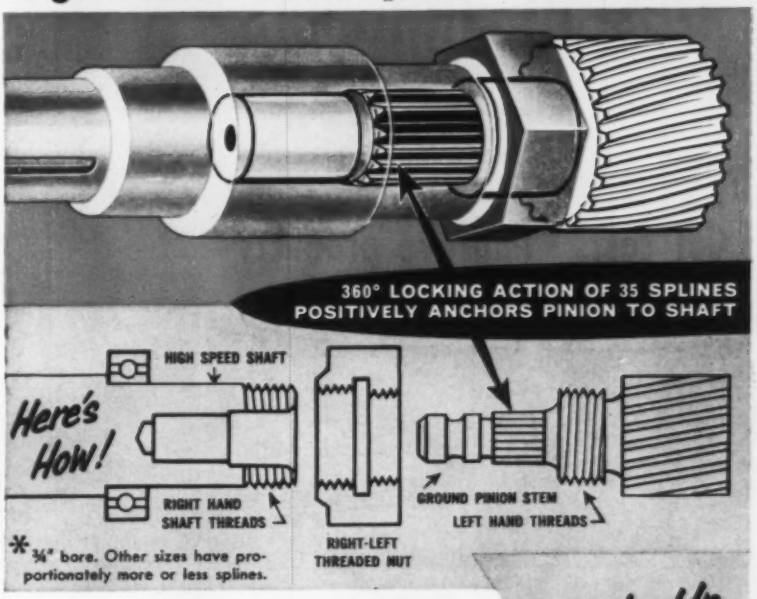
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HIGH SPEED SHAFT
Here's How!
RIGHT HAND SHAFT THREADS
RIGHT-LEFT THREADED NUT
GROUND PINION STEM
LEFT HAND THREADS

* ¾" bore. Other sizes have proportionately more or less splines.

SPLINE DRIVE PINION — advantages:

1. MORE LOCKING AREA

Self-broaching splines provide more internal locking surface than any other pinion . . . assure positive anchoring, even under reversing conditions.

2. GREATER STRENGTH

Gear and shank are machined from one piece. Solid construction and spline lock provide greater strength—no weakness due to projecting keyway.

3. PERMANENT, ACCURATE ALIGNMENT

Self-centering action of ground pinion shank in the accurately bored high speed shaft assures accurate assembly and alignment for smoother performance.

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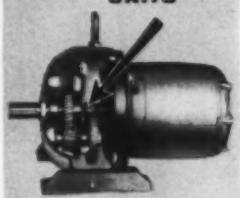
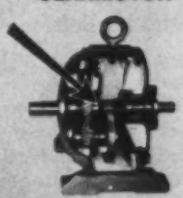


GEARMOTOR



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SPLINE DRIVE PINIONS are another example of Foote Bros. leadership . . . another reason you can be sure you're buying the finest when you buy Foote Bros. Power Transmission Equipment.

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Circle 565 on Page 19

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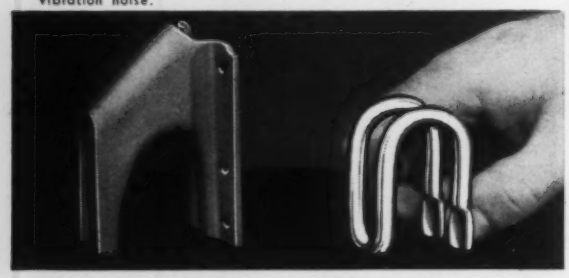

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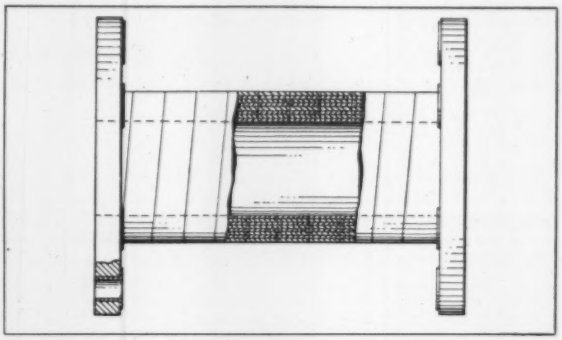
NOTEWORTHY

Patents

Glass-Fiber Torsion Spring

Energy storage elements in a high-capacity torsion spring are multiple layers of glass-fiber tape, helically wound on a hollow mandrel. To cancel compressive stresses tending to collapse the mandrel, tape is applied in successive layers, wound in the form of alternating left and right-hand helixes. Flanged ends of the spring provide for mounting. On a weight basis, torsional energy absorbed by the glass-fiber spring member equals or exceeds that of metallic types. *Patent* 2,812,936 *assigned to Ford Motor Co., Dearborn, Mich. by Henry L. Setz, Franklin Village, Mich.*



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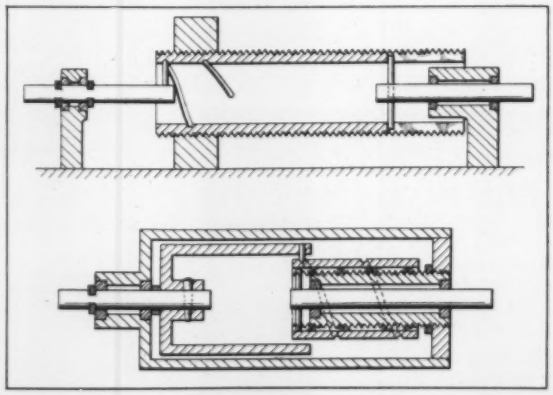
Uniform input rotation is modified to an angular-function output by a motion-transforming mechanism adapted for light or heavy-duty service. Typical application is for generating a nonlinear output from a linear potentiometer. Principal components of the mechanism are: 1. Input shaft journaled in a fixed post (right). 2. Translating drum, threaded externally and incorporating a cam groove on its inner sur-



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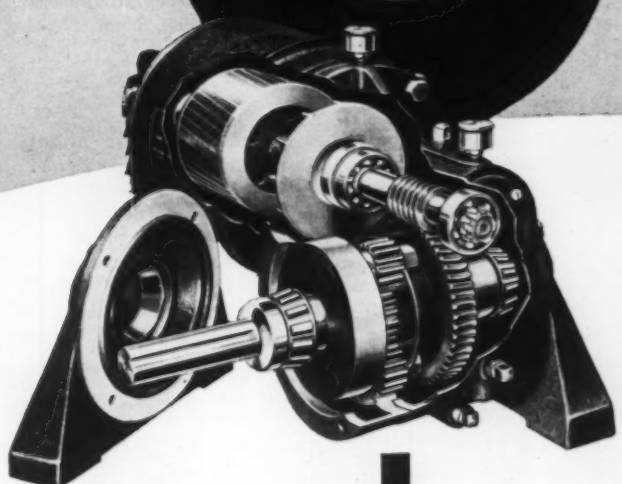

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LOW FRICTION
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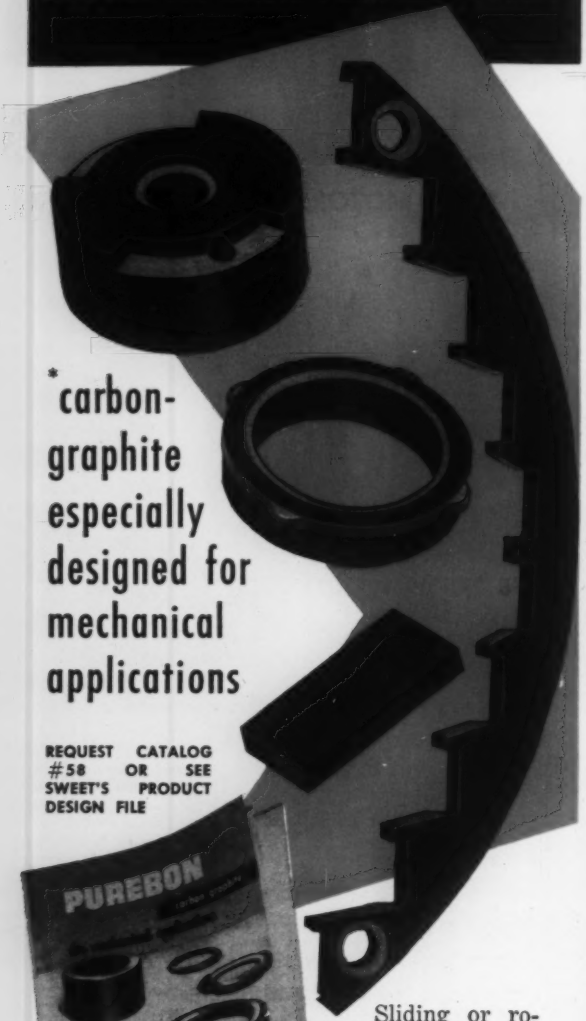

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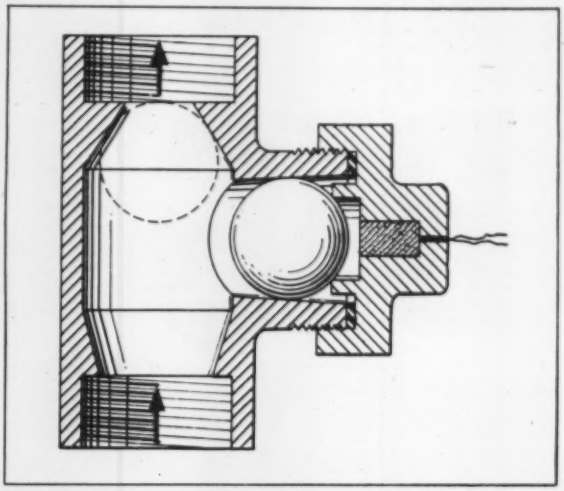
face. 3. Output shaft with perpendicular cam follower. Rotation of the input shaft forces the threaded drum to translate and rotates the output shaft in a functional manner determined by the external drum threads and the internal cam grooves. *Patent 2,818,743 assigned to Reeves Instrument Corp., New York, N. Y. by Norman C. Zatsky, Valley Stream, N. Y.*

Explosive-Operated Shutoff Valve

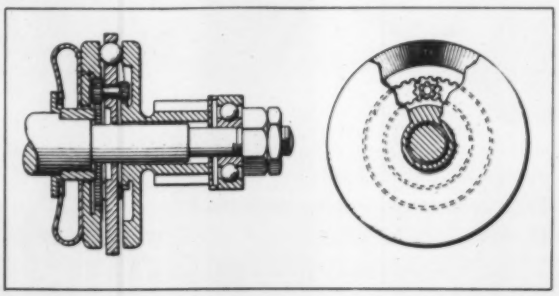
Detonation of an explosive squib provides the actuating force in a rapid-acting shutoff valve. Normally positioned to one side of the valve-body flow



passage, a spherical plug is propelled into the valve body and mates with a conical valve seat when the squib is electrically exploded. Unit has application where high-pressure flows, such as in liquid-propellant rockets, must be rapidly interrupted. *Patent 2,808,847 assigned to U.S.A. by Harvey Segal, Newark, N. J.*

Slip Clutch

Prolonged slippage has no effect on the preset breakaway torque of a preloaded slip clutch. Designed to protect prime movers driving loads against mechanical limit stops, the unit eliminates scoring, overheating, and slip-torque increase that may accompany slippage of conventional friction-type clutches. When clutch is engaged, input and output discs are mechanically coupled by multiple balls that engage wavy tracks cut in the disc surfaces. When



Circle 568 on Page 19

WARNER

electric motion control FACTS

for IDEA MEN

Only Milliseconds from Touch to Clutch for Exact Spindle Control

"Piggyback" design saves space

Here's an idea for controlling a machine drive that requires frequent, fast starts and stops.

Instantaneous response of the Warner electric clutches not only improved controllability of the machine . . . but, by using a constant-running drive motor with forward and reverse clutches as automatic power links, it was possible to reduce horsepower requirements and increase motor life.

Two clutches were mounted back to back on opposite sides of the main drive pulley, Fig. 1. Compact design permitted mounting them *inside* the pulley, which rotates freely on the drive shaft. The forward clutch rotor was keyed to the drive shaft and through gearing to the machine spindle. The reverse clutch was keyed to a free-running sleeve surrounding the drive shaft with a sprocket for powering the spindle in reverse. Both clutch fields were stationary-mounted to the machine.

Control is simple. When the forward clutch is de-energized and reverse clutch energized, the latter acts momentarily as a brake to decelerate the spindle and then as a clutch to accelerate in the opposite direction. Fast torque build-up provides precise starting, stopping, reversing, inching, and jogging. There's no coasting. Clutch armatures and rotors engage in any position, with complete engagement possible in milliseconds.

Lightens power load

This double-clutch drive eliminates motor plugging. By using a conventional electric motor operating at constant speed in one direction, horsepower rating was reduced along with power consumption. Benefits to the customer are reduced motor maintenance and longer motor life.

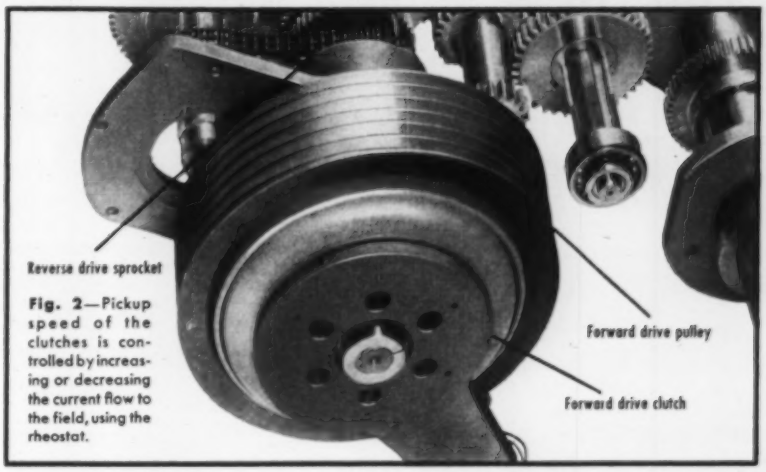
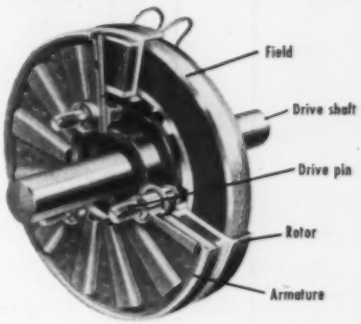


Fig. 2—Pickup speed of the clutches is controlled by increasing or decreasing the current flow to the field, using the rheostat.

Ends slip-ring troubles

Warner's stationary-field electric clutch consists simply of one stationary and two rotating members. The field is mounted to the machine frame, providing a permanent assembly of the electrical part. After extended usage, friction surfaces can be replaced easily without disturbing the coil or electrical connections. There are no slip rings or brushes. When the coil is energized, flux flows through the rotor, which attracts the armature for coupled driving. The rotor is mounted on the output shaft and is concentric to the field. The armature is mounted to the input shaft by a hub . . . or, as in this case, to a free-running pulley. It floats axially on drive pins, compensating for face wear.

Many drives like this use a constant-running motor with a split drive shaft. Here, coupling and uncoupling is controlled by mounting the rotor to one member and the armature to the other on a gear-type hub.



Exclusive advantages in Warner stationary-field electric clutches and replaceable-face electric brakes are the result of *ten* years of pioneering in the field of electric motion control.

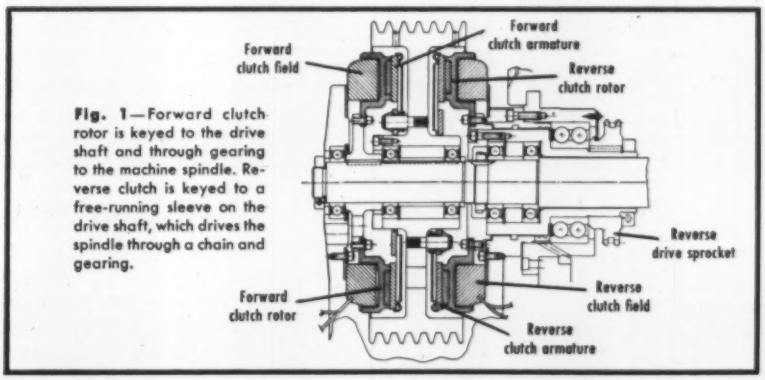


Fig. 1—Forward clutch rotor is keyed to the drive shaft and through gearing to the machine spindle. Reverse clutch is keyed to a free-running sleeve on the drive shaft, which drives the spindle through a chain and gearing.

Want more IDEAS?

Send for factual application sheets showing how machines are made more productive, easier to control, simpler to maintain with electric brakes and clutches. Write to:

Industrial Products Division,
Warner Electric Brake & Clutch Co.,
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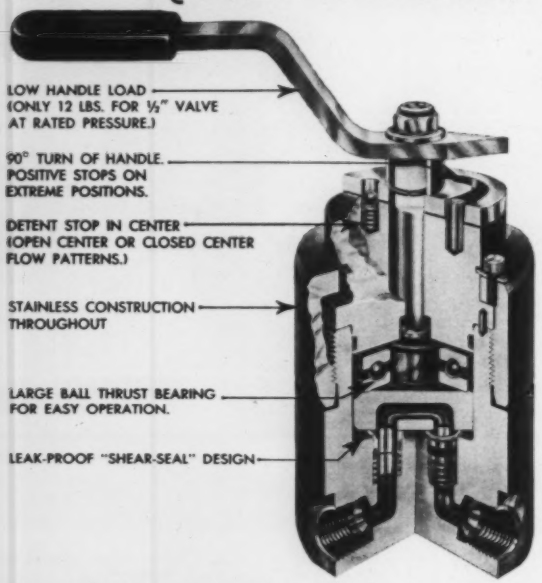
WARNER **ELECTRIC BRAKES & CLUTCHES**

Circle 569 on Page 19

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

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Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

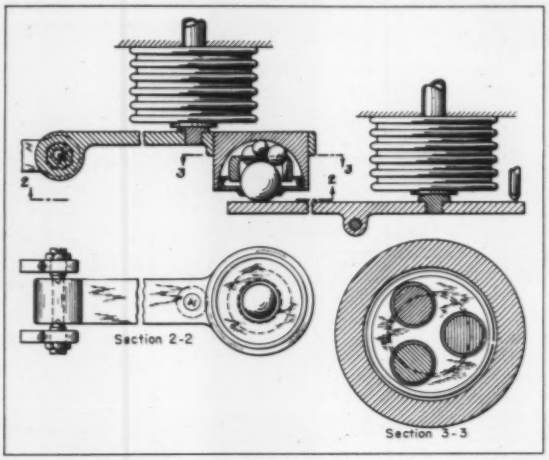
CONTROL VALVE DIVISION **barksdale valves**

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

breakaway torque is exceeded, discs separate axially, and balls roll freely along the sinusoidal tracks with minimum friction and wear. *Patent* 2,818,712 *assigned to General Electric Co., Schenectady, N. Y. by Edwin W. Barnes and Albert L. Hardy.*

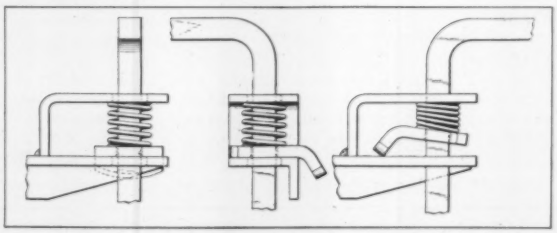
Low-Friction Contact Bearing

Sliding friction is reduced to a minimum in a multiple-ball contact-bearing assembly. Shown here in a bellows-actuated force-balancing mechanism, the



bearing comprises a central contact ball, backed up by three smaller balls in a floating retainer ring. When levers move relative to each other, the large ball rolls on the lever, and the back-up balls roll in the cup-shaped bearing housing. Sliding friction occurs only in the ball-retainer cage. *Patent* 2,818,737 *assigned to Curtiss-Wright Corp. by Hillard E. Barrett, East Orange, and Elia A. Gallo, Englewood, N. J.*

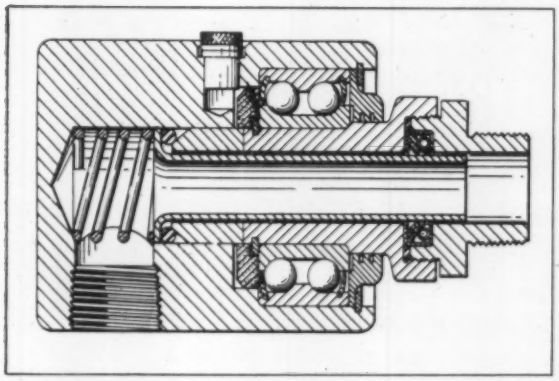
Control-Rod Lock



Push-pull rods are held securely in any position by the wedge action of a spring-loaded locking device. For use with rods of noncircular cross section, the lock is shown here in disengaged position (left and center) and in locked position (right). Quarter turn of the rod handle releases or engages the mechanism. *Patent* 2,806,385 *assigned to International Harvester Co. by Howell N. James, Moline, Ill.*

Noncorrosive Rotary Joint

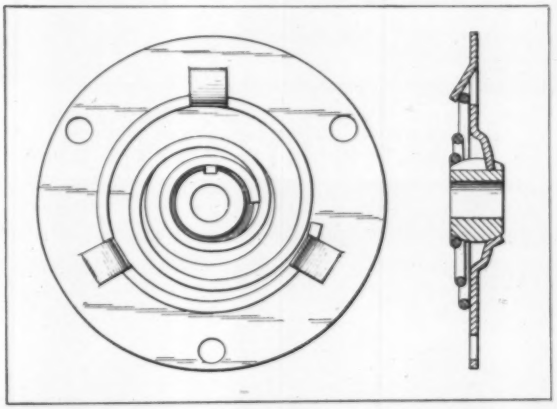
Corrosion of face-contact sealing components in a rotary air-transfer joint is minimized by auxiliary O-ring and radial seals. Function of auxiliary seals is



to confine principal air flow through the joint to a central tube, thereby protecting carbon and steel face-contact pair from contamination by air-borne moisture. Typical application is in charging and venting a pneumatic clutch, where alternating high and low pressures may condense moisture from the air. *Patent* 2,812,960 *assigned to Fawick Corp., Mich. by Joseph S. Walsh, Fairview Park, Ohio.*

Self-Aligning Bearing

Minimum axial installation space is required by a self-aligning bearing employing a conical spring as the ball-retaining member. Spring holds the spherical



bearing element in ball-and-socket relationship with its mounting plate. Economical to manufacture and easy to install, the bearing finds typical use in small electric motors. *Patent* 2,813,762 *assigned to Supreme Products Corp., Chicago, Ill. by Paul K. Bridenbaugh.*

Valve-opening area is directly proportional to control handle angular position in butterfly-type valve designed for fluid-flow metering in heating and cooling systems. Close correspondence of area and handle or stem position facilitates flow-volume control in either manual or servo-operated systems. *Patent* 2,817,489 *assigned to Dunham-Bush Inc., West Hartford, Conn. by Albert J. Hesmer, Marshalltown, Iowa.*

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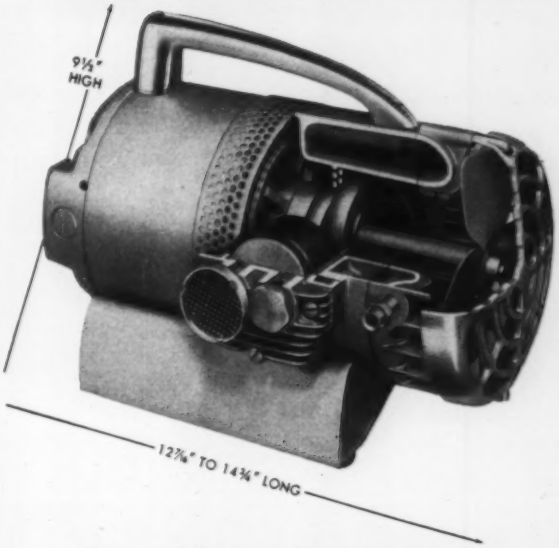

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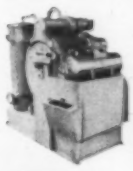

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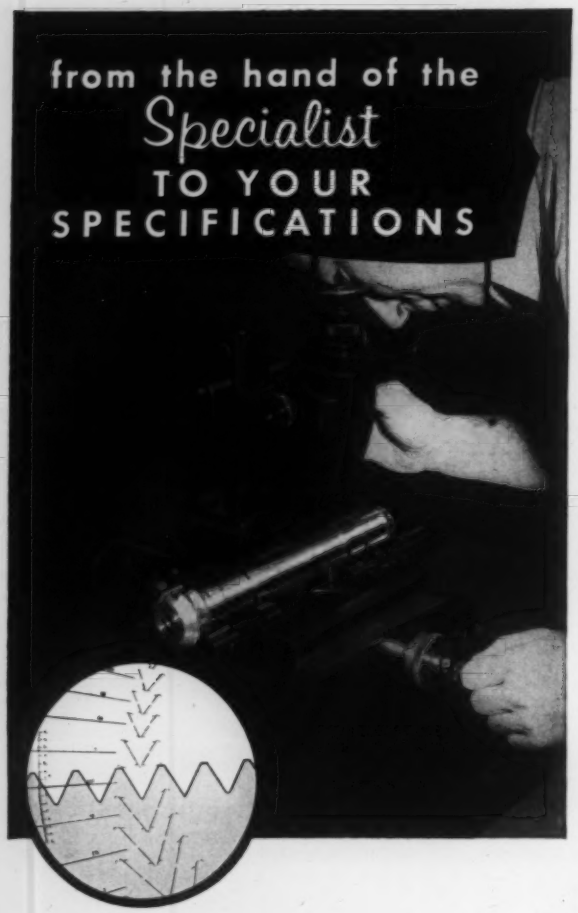

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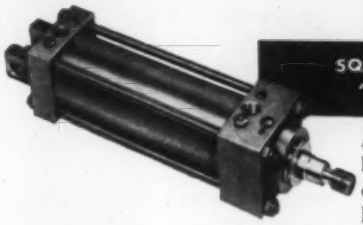

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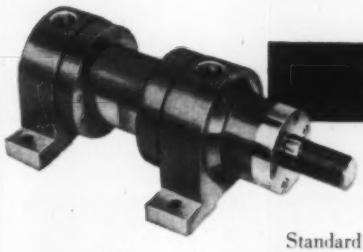

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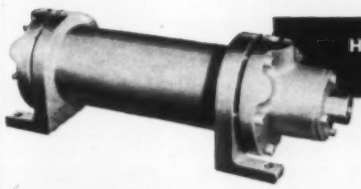

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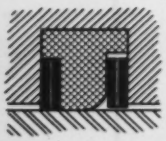

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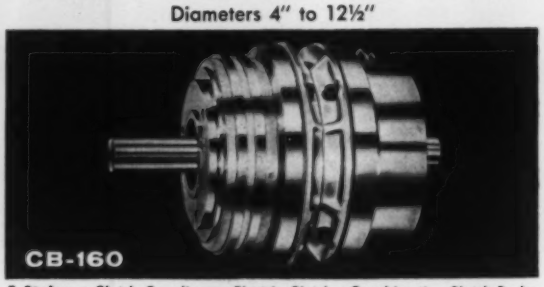

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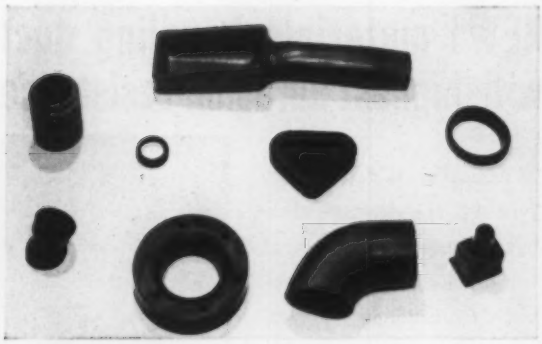

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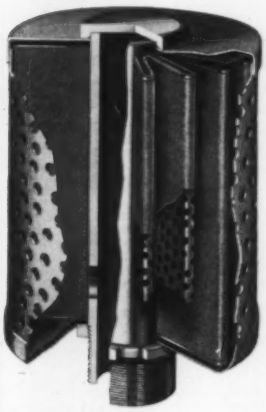

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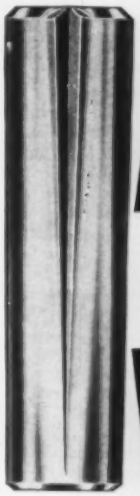

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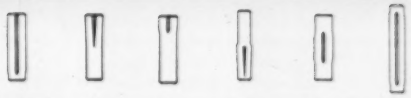

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	3/16	4400	4140	8240
	1/4	7700	7360	14720
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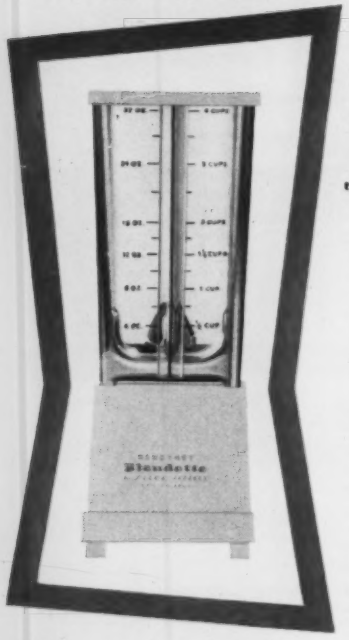

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Wiremold's new flexible duct, type 8K-1D, features abrasion-resistance and dust-tight construction, designed especially for handling dry, free-flowing materials and for heavy-duty exhaust work. Comparative tests show it to be at least 50% higher in abrasion resistance than other types. For full information, send for Folder No. 591 and Data Sheet S-12.

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other Wiremold flexible ducts for
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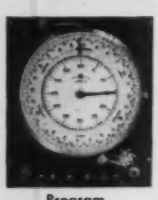
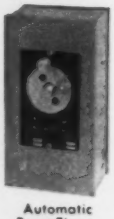


Program Timers



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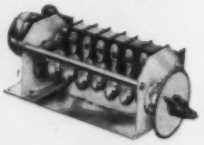

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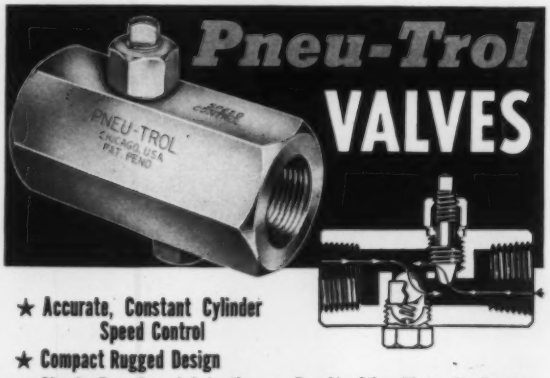

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★ **Compact Rugged Design**
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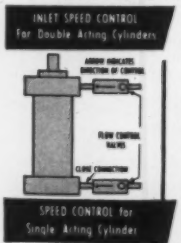

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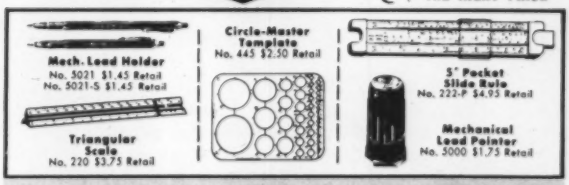

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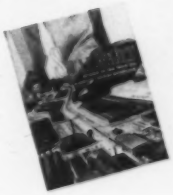

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Manufacturing plants in Jasper, Georgia and Bedford, Ohio

7846-SR

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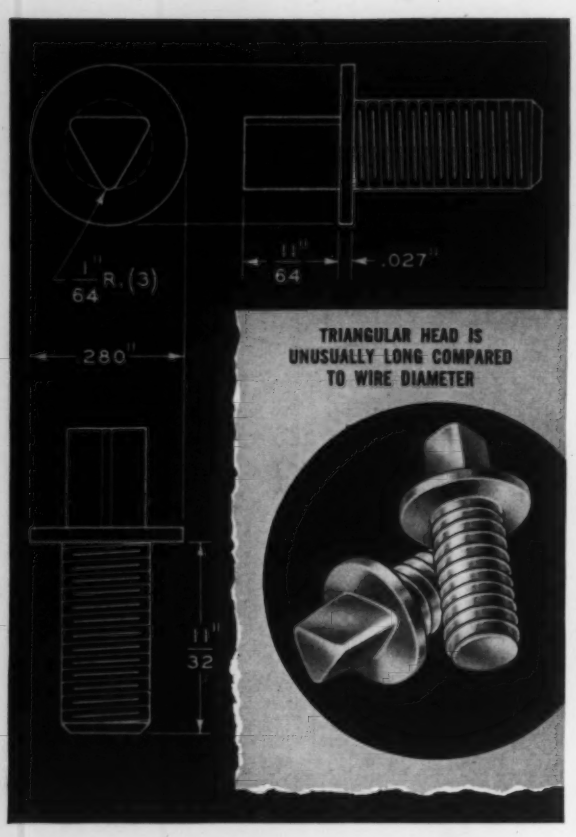

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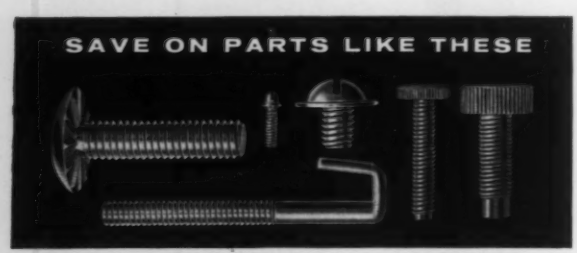

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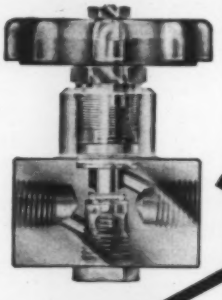

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Contains cost-reduction data for

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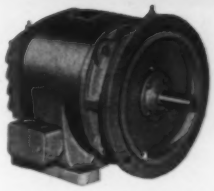
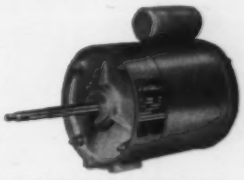
for Original Equipment Applications


NEMA "D" FLANGE

SPACE-SAVER TYPE MOTOR

EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE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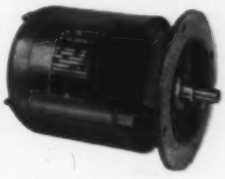
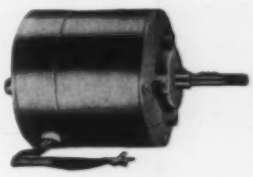

WEATHER-TIGHT SPECIAL FLANGE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ELECTRIC MOTOR DIVISION
THE *Peerless-Electric*® COMPANY
FANS • BLOWERS • MOTORS
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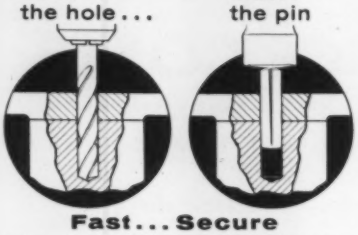

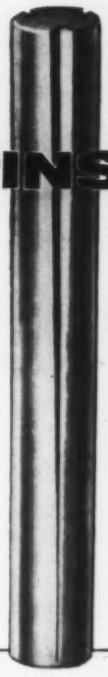

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Any machine delivers top performance only when positive-acting controls are matched to its drives. Stearns brakes and clutches start — stop — control rotary drives on applications ranging all the way from business machines and precision camera equipment to ball mills and steel mill drives. As the pioneer in this field, Stearns recognizes that a basic step in properly selecting brakes or clutches is the determination of actual torque requirements. Any of these three formulae will enable you to quickly and easily compute your specific needs.

NUMBER I

$$T = \frac{hp \times 5250}{rpm}$$

T = torque in lb ft
hp = motor hp or power source
rpm = full load speed
5250 = constant

EXAMPLE:

hp = 2
rpm = 1750
5250 = constant

$$T = \frac{2 \times 5250}{1750} = 6 \text{ lb ft}^*$$

NUMBER II — Torque lever method for line shafts or existing machines (clutches)

T = P x L
T = torque in lb ft
P = pull in lb
L = lever length

P = 40
L = 2
T = 40 x 2
T = 80* lb ft

*For clutch or brake applications, a service factor (SF) must be applied, ranging from 1 — 1.5 for light-duty, 2.0 for normal-duty, to 4.0 for heavy-duty applications.

NUMBER III — For drives having flywheels or rotating parts that must be accelerated to full rpm, or decelerated to stop in a given time where the inertia to be retarded can be determined.

$$T = \frac{WK^2 \times rpm}{308 \times t}$$

T = full load torque in lb ft
WK^2 = moment of inertia in lb ft^2 (clutches) inertia of rotating load in lb ft^2 (brakes)
W = weight in lb
K = radius of gyration in ft
t = time to accelerate in seconds from 0 to max rpm (clutches) time in seconds to stop (brakes)
308 = constant

EXAMPLE:

W = 50
K = 2
t = 3
rpm = 750

$$T = \frac{50(2^2) \times 750}{308 \times 3} =$$

T = 162 lb ft*

Whatever your torque requirements . . . design limitations . . . size or type of brake or clutch for your application . . . Stearns has it — or will design and build it for you. Stearns brakes and clutches offer velvet-smooth, quiet starts and stops that extend the service life of power source and driven machine . . . visual indication of need for adjustment . . . fast, accurate maintenance with a screw driver the *only* tool . . . important cost savings in installation and operation.

For Satisfactory Service . . . Stop and Start with Stearns!

Call the Stearns Representative in your vicinity for complete data on electro-magnetic clutches, brakes, and clutch-brake combinations. Or write, outlining your specific requirements directly to . . . 27

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

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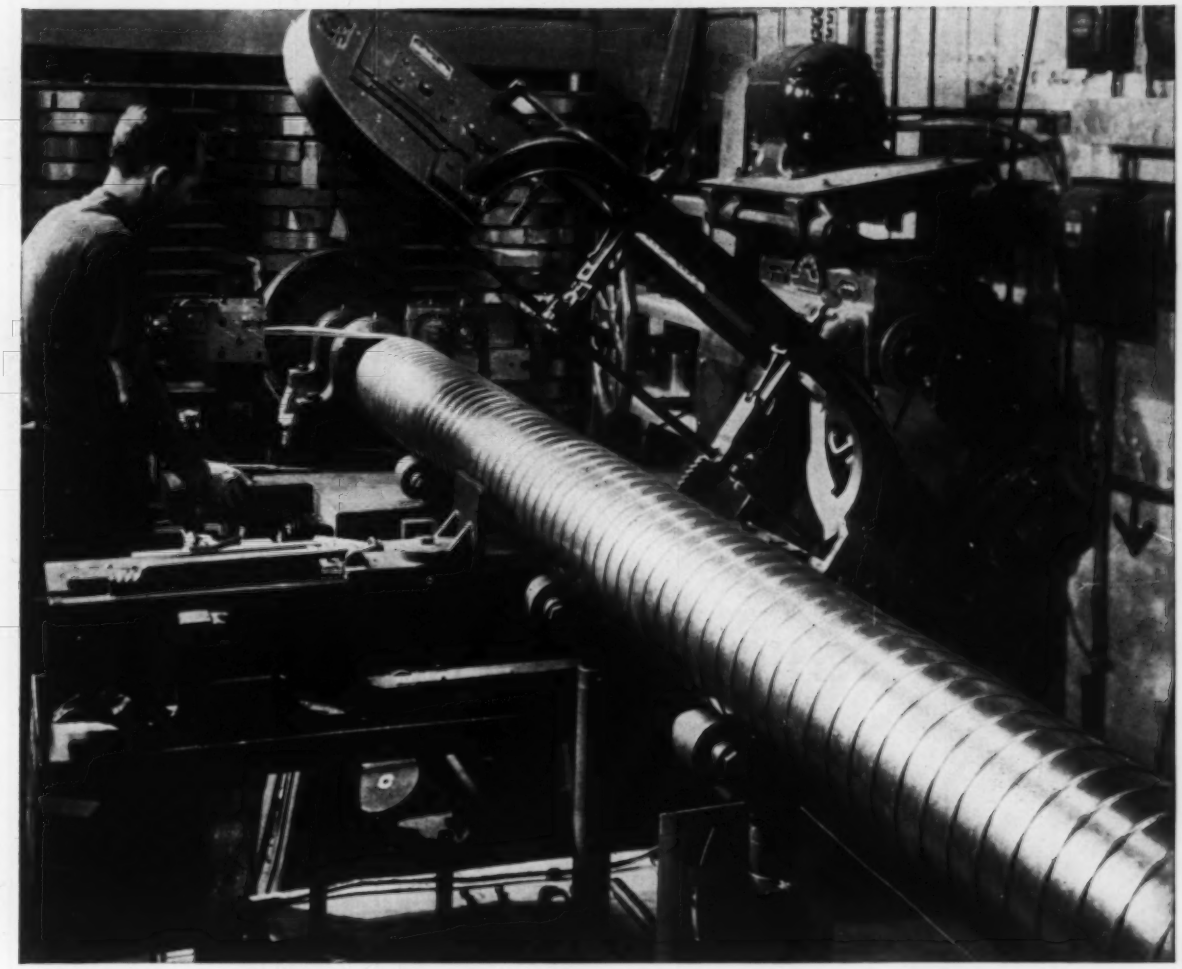
MATERIAL SELECTION



Spiral conduit from Bethcon Sheet

Here's tubing that's neither rolled to shape nor drawn to size nor welded together. It's spirally wound from a continuous ribbon of Bethcon galvanized steel!

Carrier Corporation forms this strong but lightweight conduit on a special machine in the Carrier plant at Atlanta. Each convolution of the Bethcon strip is seamed to the preceding one as shown in this sketch —▭— thus forming a reinforcing rib on the outside of the tubing. This exterior four-ply rib makes the conduit rigid, and permits a smooth interior.

By utilizing coils of Bethcon galvanized sheet Carrier has come up with a tubing that is much stronger than ordinary tubing yet weighs much less — in the 5-in. size, for example, a 10-ft length weighs but 20 lb. This obviously simplifies shipping, handling and installation.

In addition, the Bethcon galvanized coating provides long-range protection against corrosion, even at the seams. That's because Bethcon, Bethlehem's continuously galvanized product, has a coating so tight that it won't flake or peel even when the sheet is doubled back on itself.

This is just another of the many interesting ways in which industry is improving products or production with Bethcon. Where you need the strength of steel, coated for corrosion-resistance, you may find Bethcon the answer to your problem. Why not discuss its possibilities with a Bethlehem sales representative?

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Circle 600 on Page 19

Come in and see us at the DESIGN ENGINEERING SHOW!

April 14-17

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BOOTH 112

Again this year . . . the editors of MACHINE DESIGN will be on hand at the Design Engineering Show, Booth 112 to talk over your design plans and problems.

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We'll be looking forward to seeing you.

Remember Booth 112 ▶ where engineers, problems and editors meet.

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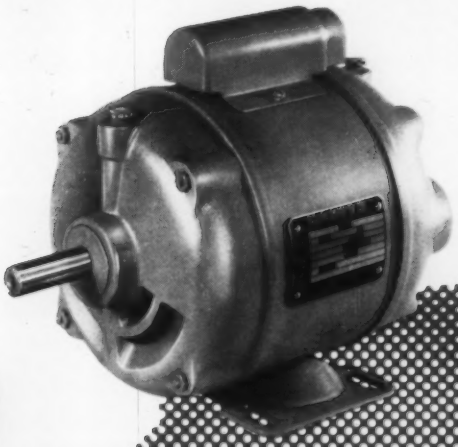

FOR 1/8 THRU 400 H. P. MOTORS

...see Master

All Enclosures—Most Types—Integrated Drives.

You get a great big plus value with Master motors—fractional and integral H.P. And that is that every one of them is engineered to meet your drive requirements *exactly*—to combine, if desired, in one tidy, efficient package with other Master components.

So for any drive requirement—simple or complex—a glance at the data below will show you that Master is your best bet. Let us tell you more.

Motor Ratings .....⅛ to 400 H.P. All phases, voltages, and frequencies.

Motor Types .....Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

Construction .....Open, enclosed, fan-cooled, explosion-proof, special purpose.

Speeds .....Single-speed, multi-speed, and variable speed.

Installation .....Horizontal or vertical, with or without flanges and other features.

Power Drive Features .....Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY • Dayton 1, Ohio

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

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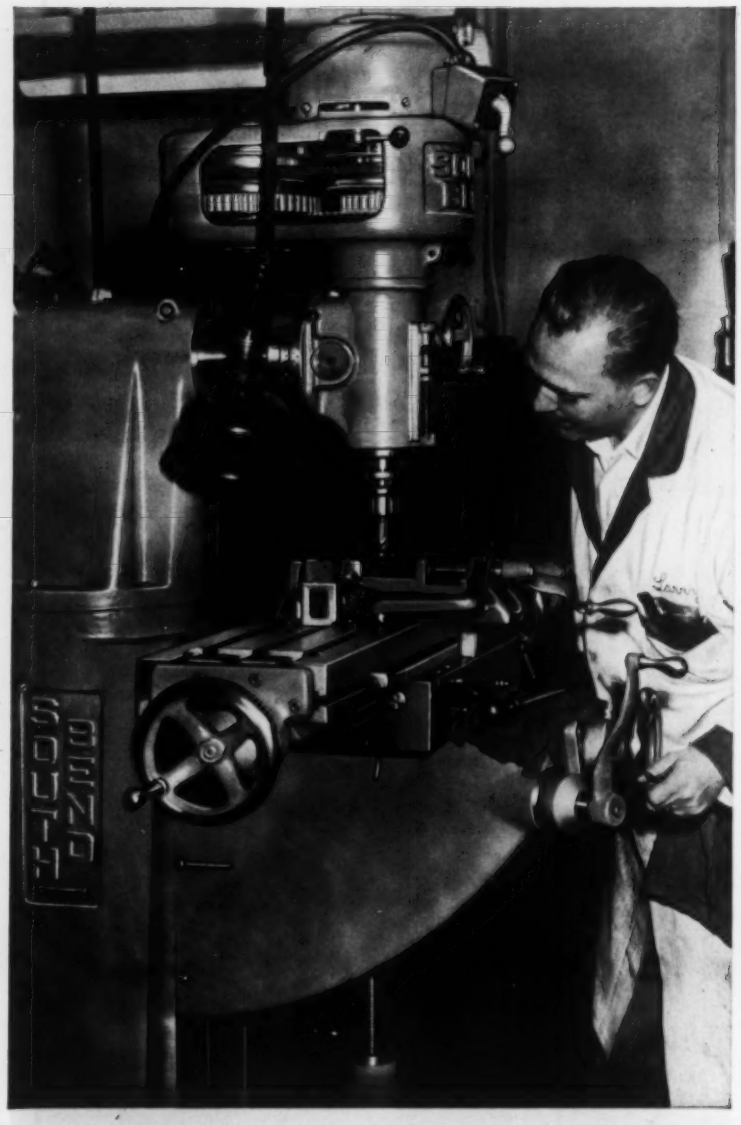
Precision milling machine spindle gets extra precision with TIMKEN® bearings



SOUTH BEND LATHE WORKS mounts the adjustable spindle of their vertical precision milling machine on two Timken tapered roller bearings to give it extra accuracy in any position. They also use Timken bearings in the elevating screw mechanism.

AT all eight speeds and at any angle, this vertical milling machine mills, drills and bores to fine tolerances. And to give the spindle extra precision in every position, South Bend Lathe Works mounts it on two Timken® tapered roller bearings. These Timken bearings:

HOLD THE SPINDLE RIGID AT ANY ANGLE. Regardless of operating position and work loads, Timken bearings keep the spindle in positive alignment. Their tapered design lets them take *both* radial and thrust loads in any combination.

TAKE HEAVY LOADS, RESIST WEAR. Full line contact between rollers and races gives Timken bearings load-carrying capacity to spare. And both rollers and races are case-carburized to give them hard, wear-resistant surfaces over tough, shock-resistant cores. They last longer, reduce maintenance.

CUT MAINTENANCE COSTS. Timken bearings hold shafts concentric with their housings. Dirt stays out; lubricant stays in. They are geometrically designed to roll true, precision-made to make sure they do. We even make our own steel. No other American bearing manufacturer takes this extra step to insure the highest quality.

Whether you buy machines or build them, make sure you get the best bearings. Look for the trade-mark "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.

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